WORKS

OF

HENRY, LORD BROUGHAM.

NATURAL THEOLOGY.

NATURAL THEOLOGY:

COMPRISING

A DISCOURSE OF NATURAL THEOLOGY,
DIALOGUES ON INSTINCT, AND
DISSERTATIONS ON THE STRUCTURE OF THE CELLS OF BEES
AND ON FOSSIL OSTEOLOGY.

Peter Brougham BY

and Vaux

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DISCOURSE

OF

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A DISCOURSE

OF

NATURAL THEOLOGY.

TO

JOHN CHARLES VISCOUNT ALTHORPE.*

THE composition of this discourse was undertaken in consequence of an observation which I had often made, that scientific men are apt to regard the study of Natural Religion as little connected with philosophical pursuits. Many of the persons to whom I allude were men of religious habits of thinking; others were free from any disposition towards scepticism, rather because they had not much discussed the subject, than because they had formed fixed opinions upon it after inquiry: but the bulk of them relied little upon Natural Theology, which they seemed to regard as a speculation built rather on fancy than on argument; or, at any rate, as a kind of knowledge quite different from either physical or moral science. It therefore appeared to me desirable to define, more precisely than had yet been done, the place and the claims of Natural Theology among the various branches of human knowledge.

About the same time our Society,† as you may recollect, was strongly urged to publish an edition of Dr. Paley's popular work, with copious and scientific illustrations. We both favoured this plan; but some of

* The late Earl Spencer. † For the Diffusion of Useful Knowledge.

our colleagues justly apprehended that the adoption of it might open the door to the introduction of religious controversy among us, against our fundamental principles; and the scheme was abandoned. I regarded it, however, as expedient to carry this plan into execution by individual exertion; and our worthy and accomplished colleague, Sir Charles Bell—whose admirable treatise on Animal Mechanics pointed him out as the fellow-labourer I should most desire—fortunately agreed to share the work of the illustrations. In these we have made a very considerable progress; and I now inscribe this publication, but particularly the Preliminary Discourse, to you. It was, with the exception of the Third Section of Part I., and the greater portion of the Notes, written at the end of 1830, in 1831, and the latter part of 1833, and a portion was added in the autumn of 1834. In those days I held the Great Seal of this kingdom; and it was impossible to finish the work while many cares of another kind pressed upon me. But the first leisure that could be obtained was devoted to this object, and to a careful revision of what had been written in a season less auspicious for such speculations.

I inscribe the fruits of those studies to you, not merely as a token of ancient friendship—for that you do not require;—nor because I always have found you, whether in possession or in resistance of power, a fellow-labourer to maintain our common principles, alike firm, faithful, disinterested — for your known public character wants no testimony from me; nor yet because a work on such a subject needs the patronage of a great name—for it would be affectation in me to pretend any such motive; but because you have devoted much of your time to such inquiries—are beyond most men sensible of their importance—concur generally in the opinions which I profess to maintain—and had even formed the design of giving to the world your thoughts upon the subject, as I hope and trust you now will be moved to do all the more for the present address. In this view, your authority will prove of great value to the cause of truth, however superfluous the patronage of even your name might be to recommend the most important of all studies.

Had our lamented friend, Romilly, lived, you are aware that not even these considerations would have made me address any one but him, with whom I had oftentimes speculated upon this ground. Both of us have been visited with the most severe afflictions, of a far nearer and more lasting kind than even his removal, and we are now left with few things to care for; yet, ever since the time I followed him to the grave, I question if either of us has read, without meditating upon the irreparable loss we and all men then sustained, the words of the ancient philosopher best imbued with religious opinions—"Proficiscar enim non ad eos solum viros, de quibus ante dixi sed etiam ad Catonem meum, quo nemo vir melior natus est, nemo pietate præstantior; cujus a me corpus crematum est animus vero non me deserens, sed respectans, in ea profecto loca discessit, quo mihi ipsi cernebat esse veniendum; quem ego meum casum fortiter ferre visus sum, non quo æquo animo ferrem; sed me ipse consolabar, existimans, non longinquum inter nos digressum et discessum fore." *

* "For I shall go not only to meet those of whom I have been speaking, but also to my Cato, than whom a better man never was born, nor one of more eminent piety, whose remains I attended to the grave; while his soul, not quitting, but looking down upon me, departed to those regions whither he saw I should follow—a loss which I seemed to bear with fortitude, not because I could sustain it with an equal mind, but because I consoled myself with the reflection that the interval between our separation and our meeting could not be long."—*Cicero De Senectate.*

INTRODUCTION.

ARRANGEMENT OF SUBJECTS AND EXPLANATION OF TERMS.

THE words *Theology* and *Religion* are often used as synonymous. Thus *Natural Theology* and *Natural Religion* are by many confounded together. But the more accurate use of the words is that which makes *Theology* the science, and *Religion* its subject; and in this manner are they distinguished when we speak of a "professor of theology," and a "sense of religion."

There is, however, as regards *Natural Theology*, a more limited use of the word, which confines it to the knowledge and attributes of the Deity, and regards the speculation concerning his will, and our hopes from and duties towards him, as another branch of the science, termed *Natural Religion*, in contradistinction to the former. Dr. Paley hardly touches on this latter branch in his book, there being only about one-sixtieth part devoted to it, and that incidentally in treating of the attributes. Indeed, though in the dedication he uses the word *Religion* as synonymous with *Theology*, the title and the arrangement of his discourse show that he generally employed the term *Natural Theology* in its restricted sense. Bishop Butler, on the other hand, seems to have used *Natural Religion* in a sense equally restricted, but certainly little warranted by custom; for that portion of his work which treats of Natural Religion is confined to a future state and the moral government of God, as if he either held

Natural Religion and Natural Theology to be two branches of one subject, or Natural Religion to be a branch of Natural Theology. The older writers, Clarke, Bentley, Derham, seem to have sometimes used the words indifferently, but never to have regarded Natural Religion in the restricted acceptation. The ancients generally used *Religion* in a qualified sense, either as connected with an obligation, or as synonymous with superstition.

This Discourse is not a treatise of Natural Theology: it has not for its design an exposition of the doctrines whereof Natural Theology consists. But its object is, first, to explain the nature of the evidence upon which it rests—to show that it is a science, the truths of which are discovered by induction, like the truths of Natural and Moral Philosophy—that it is a branch of science partaking of the nature of each of those great divisions of human knowledge, and not merely closely allied to them both. Secondly, the object of the Discourse is to explain the advantages attending this study. The work, therefore, is a *logical* one.

We have commented upon the use of the terms *Theology* and *Religion*. As it is highly desirable to keep scientific language precise, and always to use the same terms in the same sense, we shall now further observe upon the word "*moral*" in relation to science or faculties. It is sometimes used to denote the whole of our mental faculties, and in opposition to natural and physical, as when we speak of "*moral science*," "*moral truths*," "*moral philosophy*." But it is also used in contradistinction to "*intellectual*" or "*mental*," and in connection with or in reference to obligation; and then it relates to rights and duties, and is synonymous with *ethical*. It seems advisable to use it always in this sense, and to employ the words *spiritual* and *mental* in opposition to *natural* and *material*; and *psychological*, as applied to the science of mind, in opposition to *physical*. Again, a distinction is sometimes made between the *intellectual* and *moral* powers or faculties—the former being those of the understanding, the latter those of the will, or, as they are often called, the "*active powers*,"—that is, the passions and feelings. It seems better to use the word *active* for this purpose as opposed to *intellectual*. Thus we shall first have these general terms, *spiritual* or *mental*, as applied to the immaterial part of the creation, and *psychological*, as applied to the science which treats of it. We shall next have a subdivision of the mental faculties into *intellectual* and *active*; both form the subjects of *psychological* science. *Moral* science, in its restricted sense, and properly so called, will then denote that branch which treats of duties, and of what is implied in those duties, their correlative rights: it will, in short, be *ethical* science.

Thus the science of mind—say *Metaphysical* science—may be said to consist of two great branches, the one of which treats of existences, the other of duties. The one accordingly has been termed with great accuracy, *Ontology*, speaking of that which *is*; the other, *Deontology*, speaking of that which *ought to be*. The former, however, comprehends properly all physical as well as mental science. The division which appears upon the whole most convenient is this: That *metaphysical* science, as contradistinguished from *physical*, is either *psychological*, which treats of the faculties both intellectual and active, but treats of existences only; or *moral*, which treats of rights and duties, and is distinguishable from psychological, though plainly connected with it nearly as corollaries are with the propositions from whence they flow. Then physical truths, in one respect, come under the same head with the first branch of metaphysical truths. Physical as well as psychological science treats of existences, while moral science alone treats of duties.

According to a like arrangement, Natural Theology consists of two great branches, one resembling *Onto-*

logy, the other analogous to *Deontology*. The former comprehends the discovery of the existence and attributes of a Creator, by investigating the evidences of design in the works of the creation, material as well as spiritual. The latter relates to the discovery of his will and probable intentions with regard to his creatures, their conduct and their duty. The former resembles the physical and psychological sciences, and treats of the evidences of design, wisdom, and goodness exhibited both in the natural and spiritual worlds.

The latter resembles rather the department of moral science, as distinguished from both physical and psychological. We may thus consider the science of Natural Theology as consisting, like all inductive science, of three compartments, Natural, Mental, and Moral; or, taking the Greek terms, Physical, Psychological, and Ethical.

This classification is convenient, and its grounds are very fit to be premised—at the same time that we must admit the question to be one only of classification and technology. Having so stated the divisions of the subject, and the meaning of the terms used in relation to those divisions, I shall assume this arrangement and adhere to this phraseology, as convenient, though far from representing it to be the best. In such discussions it is far more important to employ one uniform and previously explained language or arrangement, than to be very curious in adopting the best. No classification indeed can, from the nature of things, be rigorously exact. All the branches of science, even of natural philosophy, much more of metaphysical, run into each other, and are separated by gradations rather than by lines of demarcation. Nor could any scientific language we possess help breaking down under us in an attempt to maintain a perfectly logical arrangement.*

* Note I.

Analysis of the Work.

The order of this Discourse is thus set out:—

The First Part treats of the nature of the subject, and the kind of evidence upon which Natural Theology rests.

The Second Part treats of the advantages derived from the study of the science.

The former Part is divided into seven sections. The *first* is introductory, and treats of the kind of evidence by which the truths of Physical and Psychological science are investigated, and shows there is as great an appearance of diversity between the manner in which we arrive at the knowledge of different truths in those inductive sciences, as there is between the nature of any such inductive investigation and the proofs of the ontological branches of Natural Theology. But that diversity is proved to be only apparent; and hence it is inferred, that the supposed difference in the proofs of Natural Theology may also be only apparent.

The *second* section continues the application of this argument to the Physical branch of Natural Theology, and shows further proofs that the first branch of Natural Theology is as much an inductive science as Physics or Natural Philosophy. The first section compared the ontological branches of Natural Theology with all inductive science, physical as well as psychological. The second compares the physical branch of Natural Theology with physical science only.

The *third* section compares the psychological branch of Natural Theology with psychological science, and shows that both rest alike upon induction.

The *fourth* section shows that the *argumentum à priori* is unsound to a great degree—that it is insufficient for the purpose to which it is applied—that it serves only to a limited extent—and that to this extent it is in reality not distinguishable from induction, or the *argumentum à posteriori.*

The *fifth* section treats of the second or Moral,—the *deontological* branch of Natural Theology, and shows that it rests upon the same kind of evidence with moral science, and is, strictly speaking, as much a branch of inductive knowledge.

The *sixth* section examines the doctrines of Lord Bacon respecting Final Causes, and shows that he was not adverse to the speculation when kept within due bounds.

The *seventh* section examines the true nature of inductive analysis and synthesis, and points out some important errors prevailing on this subject.

In treating of the proofs of design displayed by the mental constitution of living creatures, and in treating of the Soul's immortality, it becomes necessary to enter more at large into the subject, and therefore the *third* and the *fifth* sections are not, like the others, mere logical discourses in which the doctrines of Natural Theology are assumed rather than explained. The subjects of those two sections have not been sufficiently handled in professed treatises upon Natural Theology, which have been almost wholly confined to the first branch of the science—the proofs of the Deity's existence and attributes—and to the physical portion of that branch. This defect I have endeavoured to supply.

The Second Part, which treats of the advantages of the study, consists of three sections.

The *first* shows that the precise kind of pleasure derived from the investigation of scientific truths is derived from this study.

The *second* treats of the pleasures which are peculiar to this study.

The *third* treats of the connection of Natural with Revealed Religion.*

* I have heard it said that some ideas in one part of this Discourse had been anticipated by a work of Dr. Crombie. That such coincidence is purely accidental must appear from this, that having mislaid his book when it reached me, I have never read one line of it to this hour.—*Sept.* 1845.

PART THE FIRST.

NATURE OF THE SCIENCE, AND OF ITS EVIDENCES.

SECTION I.

INTRODUCTORY VIEW OF THE METHOD OF INVESTIGATION PURSUED IN THE PHYSICAL AND PSYCHOLOGICAL SCIENCES.

THE faculties as well as the feelings of the human mind, its intellectual as well as its active powers, are employed without any intermission, although with varying degrees of exertion, in one of two ways—either in regard to some object immediately connected with the supply of our wants, or in regard to subjects of mere contemplation. The first class of exertions relates to all the objects of necessity, of comfort, or of physical enjoyment: in the pursuit of these, the powers of the understanding, or the passions, or both together, are, with nearly the whole of mankind, employed during the greater portion of their existence, and, with the bulk of mankind, during almost the whole of their existence. The other class of mental exertions, which engrosses but a very few men for the greater part of their lives, and occupies the majority only occasionally and at considerable intervals, comprehends within its scope all the subjects of meditation and reflection—of merely speculative reasoning and discussion: it is composed of all the efforts which our understanding can make, and all the desires which we can feel, upon subjects of mere science or taste, matters which begin and end in intellectual or moral gratification.

It is unquestionably true that these two grand branches of exertion have an intimate connexion with each other. The pursuits of science lend constant assistance to those of active life; and the practical exercise of the mental powers constantly furthers the progress of science merely speculative. But the two provinces are nevertheless perfectly distinguishable, and ought not to be confounded. The corollary from a scientific discovery may be the improvement of a very ordinary machine or a common working tool; yet the establishment of the speculative truth may have been the primary object of the philosopher who discovered it; and to learn that truth is the immediate purpose of him who studies the philosopher's system. So the better regulation of the affections or the more entire control of the passions may be the result of an acquaintance with our mental constitution; but the object of him who studies the laws of mind is merely to become acquainted with the spiritual part of our nature. In like manner, it is very possible that the knowledge of a scientific truth may force itself upon one whose faculties or feelings are primarily engaged in some active exertion. Some physical law, or some psychological truth, may be discovered by one only intent upon supplying a physical want, or obtaining a mental enjoyment. But here, as in the former case, the scientific or speculative object is only incidental or collateral to the main pursuit: the matter of contemplation is the corollary, the matter of action the proposition.

The merely contemplative pursuits which thus form one of the great branches of mental exertion seem again to be divisible into two classes, by a line that, to a careless observer, appears sufficiently defined. The objects of our inquiry and meditation appear to be either those things in the physical and spiritual worlds with which we are conversant through our senses or by means of our internal consciousness, or those things with which we are made acquainted only by reasoning—by the evidence of things unseen and unfelt. We either discuss the properties and relations of actually perceived and conceived beings, physical and mental —that is, the objects of sense and of consciousness— or we carry our inquiries beyond those things which we see and feel; we investigate the origin of them and of ourselves; we rise from the contemplation of nature and of the spirit within us, to the first cause of all, both of body and of mind. To the one class of speculation belong the inquiries how matter and mind are framed, and how they act; to the other class belong the inquiries whence they proceed, and whither they tend. In a word, the structure and relations of the universe form the subject of the one branch of philosophy, and may be termed *Human Science;* the origin and destiny of the universe forms the subject of its other branch, and is termed *Divine Science,* or *Theology.*

It is not to be denied that this classification may be convenient; indeed, it rests upon some real foundation; for the speculations which compose these two branches have certain common differences and common resemblances. Yet it is equally certain, that nothing but an imperfect knowledge of the subject, or a superficial attention to it, can permit us to think that there is any well-defined boundary which separates the two kinds of philosophy; that the methods of investigation are different in each; and that the kind of evidence varies by which the truths of the one and of the other class are demonstrated. The error is far more extensive in its consequences than a mere inaccuracy of classification; for it materially impairs the force of the proofs upon which Natural Theology rests. The proposition which I would place in its stead is, That this science is strictly a branch of inductive philosophy, formed and supported by the same kind of reasoning upon which the Physical and Psychological sciences are founded. This important point will be established by a fuller explanation; and we shall best set about this task by showing in the first place, that the same apparent diversity of evidence exists in the different subjects or departments of the branch which we have termed Human science. It seems to exist there on a superficial examination: if a closer scrutiny puts that appearance to flight, the inference is legitimate, that there may be no better ground for admitting an essential difference between the foundations of Human Science and Divine.

The careless inquirer into physical truth would certainly think he had seized on a sound principle of classification, if he should divide the objects with which philosophy, Natural and Mental, is conversant, into two classes—those objects of which we know the existence by our senses or our consciousness; that is, external objects which we see, touch, taste, and smell, internal ideas which we conceive or remember, or emotions which we feel—and those objects of which we only know the existence by a process of reasoning, founded upon something originally presented by the senses or by consciousness. The superficial reasoner would range under the first of these heads the members of the animal, vegetable, and mineral kingdoms; the heavenly bodies; the mind—for we are supposing him to be so far capable of reflection as to know that the proof of the mind's separate existence is, at the least, as short, plain and direct, as that of the body, or of external objects. Under the second head he would range generally whatever objects of examination are not directly perceived by the senses, or felt by consciousness.

But a moment's reflection will show both how very short a way this classification would carry our inaccurate logician, and how entirely his principle fails to support him even during that little part of the journey. Thus the examination of certain visible objects and appearances enables us to ascertain the laws of light and of vision. Our senses teach us that colours differ, and that their mixture forms other hues; that their absence is black, their combination in certain proportions white. We are in the same way enabled to understand that the organ of vision performs its functions by a natural apparatus resembling, though far surpassing, certain instruments of our own constructing, and that therefore it works on the same principles. But that light, which can be perceived directly by none of our senses, exists as a separate body, we only infer by a process of reasoning from things which our senses do perceive. So we are acquainted with the effects of heat; we know that it extends the dimensions of whatever matter it penetrates; we feel its effects upon our own nerves when subjected to its operation; and we see its effects in augmenting, liquefying, and decomposing other bodies; but its existence as a separate substance we do not know, except by reasoning and by analogy. Again, to which of the two classes must we refer the air? Its existence is not made known by the sight, the smell, the taste; but is it by the touch? Assuredly a stream of it blown upon the nerves of touch produces a certain effect; but to infer from thence the existence of a rare, light, invisible, and impalpable fluid, is clearly an operation of reasoning, as much as that which enables us to infer the existence of light or heat from their perceptible effects. But furthermore, we are accustomed to speak of seeing motion; and the reasoner whom we are supposing would certainly class the phenomena of mechanics, and possibly of dynamics generally, including astronomy, under his first head, of things known immediately by the senses. Yet assuredly nothing can be more certain than that the knowledge of motion is a deduction of reasoning, not a perception of sense; it is derived from the comparison of two positions: the idea of a change of place is the result of that comparison attained by a short process of reasoning; and the estimate of velocity is the result of another process of reasoning and of recollection. Thus, then, there is at once excluded from the first class almost the whole range of natural philosophy. But are we quite sure that anything remains which when severely examined will stand the test? Let us attend a little more closely to the things which we have passed over hastily, as if admitting that they belonged to the first class.

It is said that we do not see light, and we certainly can know its existence directly by no other sense but that of sight, but that we see objects variously illuminated, and therefore that the existence of light is an inference of reason, and the diversity of colour an object of sense. But the very idea of diversity implies reasoning, for it is the result of a comparison; and when we affirm that white light is composed of the seven primary colours in certain proportions, we state a proposition which is the result of much reasoning—reasoning, it is true, founded upon sensations or impressions upon the senses; but not less founded upon such sensations is the reasoning which makes us believe in the existence of a body called light. The same may be said of heat and the phenomena of heated bodies. The existence of heat is an inference from certain phenomena, that is, certain effects produced on our external senses by certain bodies, or certain changes which those senses undergo in the neighbourhood of those bodies; but it is not more an inference of reason than the proposition that heat extends or liquefies bodies, for that is merely a conclusion drawn from comparing our sensations occasioned by the external objects placed in varying circumstances.

But can we say that there is no process of reasoning even in the simplest case which we have supposed our reasoner to put—the existence of the three kingdoms; of nature, of the heavenly bodies, of the mind? It is certain that there is in every one of these cases a process of reasoning. A certain sensation is excited in the mind through the sense of vision; it is an inference of reason that this must have been excited by something, or must have had a cause. That the cause must have been external may possibly be allowed to be another inference which reason could make unaided by the evidence of any other sense. But to discover that the cause was at any the least distance from the organ of vision clearly required a new process of reasoning, considerable experience, and the indications of other senses; for the young man whom Mr. Cheselden couched for a cataract at first believed that everything he saw touched his eye. Experience and reasoning, therefore, are required to teach us the existence of external objects; and all that relates to their relations of size, colour, motion, habits, in a word, the whole philosophy of them, must of course be the result of still longer and more complicated processes of reasoning. So of the existence of the mind: although undoubtedly the process of reasoning is here the shortest of all and the least liable to deception, yet so connected are all its phenomena with those of the body, that it requires a process of abstraction alien from the ordinary habits of most men, to be persuaded that we have a more undeniable evidence of its separate existence than we even have of the separate existence of the body.

It thus clearly appears that we have been justified in calling the classifier whose case we have been supposing, a careless inquirer, a superficial reasoner, an imperfect logician; that there is no real foundation for the distinction which we have supposed him to take between the different objects of scientific investigation; that the evidence upon which our assent to both classes of truths reposes is of the same kind, namely, the inferences drawn by reasoning from sensations or ideas originally presented by the external senses, or by our inward consciousness.

If, then, the distinction which at first appeared solid is found to be without any warrant in the different kinds of human science, has it any better grounds when we apply it to draw the line between that branch of philosophy itself, and the other which has been termed Divine, or theology? In other words, is there any real, any specific difference between the method of investigation, the nature of the evidence, in the two departments of speculation? Although this preliminary discourse, and indeed the work itself which it introduces, and all the illustrations of it, are calculated throughout to furnish the answer to the question, we shall yet add a few particulars in this place, in order to show how precisely the same fallacy which we have been exposing, in regard to the classification of objects in ordinary scientific research, gives rise to the more general classification or separation of all science into two distinct branches, human and divine, and how erroneous it is to suppose that these two branches rest upon different foundations.

SECTION II.

COMPARISON OF THE PHYSICAL BRANCH OF NATURAL THEOLOGY WITH PHYSICS.

THE two inquiries—that into the nature and constitution of the universe, and that into the evidence of design which it displays—in a word, physics and psychology, philosophy whether natural and mental, and the fundamental branch of Natural Theology,—are not only closely allied one to the other, but are to a very considerable extent identical. The two paths of investigation for a great part of the way completely coincide. The same induction of facts which leads us to a knowledge of the structure of the eye, and its functions in the animal economy, leads us to the knowledge of its adaptation to the properties of light. It is a truth of physics, in the strictest sense of the word, that vision is performed by the eye refracting light, and making it converge to a focus upon the retina; and that the peculiar combination of its lenses, and the different materials they are composed of, correct the indistinctness which would otherwise arise from the different refrangibility of light; in other words, make the eye an achromatic instrument. But if this is not also a truth in Natural Theology, it is a position from which, by the shortest possible process of reasoning, we arrive at a theological truth—namely, that the instrument so successfully performing a given service by means of this curious structure, must have been formed with a knowledge of the properties of light. The position from which so easy a step brings us to this doctrine of Natural Theology was gained by strict induction. Upon the same evidence which all natural science rests on, reposes the knowledge that the eye is an optical instrument: this is a truth common to both Physics and Theology. Before the days of Sir Isaac Newton men knew that they saw by means of the eye, and that the eye was constructed upon optical principles; but the reason of its peculiar conformation they knew not, because they were ignorant of the different refrangibility of light. When his discoveries taught this truth, it was found to have been acted upon, and consequently known, by the Being who created the eye. Still our knowledge was imperfect; and it was reserved for Mr. Dollond to discover another law of nature — the different dispersive powers of different substances—which enabled him to compound an object-glass that more effectually corrected the various refrangibility of the rays. It was now observed that this truth also must have been known to the maker of the eye; for upon its basis is that instrument, far more perfect than the achromatic glass of Dollond, framed. These things are truths in both physics and theology; they are truths taught us by the self-same process of investigation, and resting upon the self-same kind of evidence.

When we extend our inquiries, and observe the varieties of this perfect instrument, we mark the adaptation of changes to the diversity of circumstances, as in different animals: and the truths thus learnt are in like manner common to Physical and Theological science; that is, to Natural History, or Comparative Anatomy, and Natural Theology.

That beautiful instrument, so artistly contrived that the most ingenious workman could not imagine an improvement of it, becomes still more interesting and more wonderful, when we find that its conformation is varied with the different necessities of each animal. If the animal prowls by night, we see the opening of the pupil, and the power of concentration in the eye increased. If an amphibious animal has occasionally to dive into the water, with the change of the medium through which the rays pass there is an accommodation in the condition of the humours, and the eye partakes of the eye both of the quadruped and of the fish.

So, having contemplated the apparatus for protection in the human eye, we find that in the lower animals, who want both the accessory means of cleaning the eye and the ingenuity to accomplish it by other modes than the eyelids, an additional eyelid, a new apparatus, is provided for this purpose.

Again, in fishes, whose eye is washed by the element in which they move, all the exterior apparatus is unnecessary, and is dismissed; but in the crab, and especially in that species which lies in mud, the very peculiar and horny prominent eye, which everybody must have observed, would be quite obscured were it not for a particular provision. There is a little brush of hair above the eye, against which the eye is occasionally raised to wipe off what may adhere to it. The form of the eye, the particular mode in which it is moved, and, we may say, the coarseness of the instrument compared with the parts of the same organ in the higher class of animals, make the mechanism of eyelids and of lachrymal glands unsuitable. The mechanism used for this purpose is discovered by observation and reasoning: that it is contrived for this purpose is equally a discovery of observation and reasoning. Both propositions are strictly propositions of physical science.

The same remarks apply to every part of the animal body. The use to which each member is subservient, and the manner in which it is enabled so to perform its functions as to serve that appointed use, is learnt by an induction of the strictest kind. But it is impossible to deny, that what induction thus teaches forms the great bulk of all Natural Theology. The question which the theologian always puts upon each discovery of a purpose manifestly accomplished is this: "Suppose I had this operation to perform by mechanical means, and were acquainted with the laws regulating the action of matter, should I attempt it in any other way than I here see practised?" If the answer is in the negative, the consequence is irresistible, that some power, capable of acting with design, and possessing the supposed knowledge, employed the means which we see used. But this negative answer is the result of reasoning founded upon induction, and rests upon the same evidence whereon the doctrines of all physical science are discovered and believed. And the inference to which that negative answer so inevitably leads is a truth in Natural Theology; for it is only another way of asserting that design and knowledge are evinced in the works and functions of nature.

It may further illustrate the argument to take one or two other examples. When a bird's egg is examined, it is found to consist of three parts; the chick, the yolk in which the chick is placed, and the white in which the yolk swims. The yolk is lighter than the white; and is attached to it at two points by the treadles. If a line were drawn through these two points it would pass below the centre of gravity of the yolk. From this arrangement it must follow that the chick is always uppermost, roll the egg how you will; consequently, the chick is always kept nearest to the breast or belly of the mother while she is sitting. Suppose, then, that any one acquainted with the laws of motion had to contrive things so as to secure this position for the little speck or sac in question, in order to its receiving the necessary heat from the hen—could he proceed otherwise than by placing it in the lighter liquid, and suspending that liquid in the heavier, so that its centre of gravity should be above the line or plane of suspension? Assuredly not; for in no other way could his purpose be accomplished. This position is attained by a strict induction; it is supported by the same kind of evidence on which all physical truths rest. But it leads by a single step to another truth in Natural Theology; that the egg must have been formed by some hand skilful in mechanism, and acting with the knowledge of dynamics.

The forms of the bones and joints, and the tendons or cords which play over them, afford a variety of instances of the most perfect mechanical adjustment. Sometimes the power is sacrificed for rapidity of motion, and sometimes rapidity is sacrificed for power. Our knee-pan, or patella, (*ligamentum patellae,*) throws off the tendon which is attached to it from the centre of motion, and therefore adds to the power of the muscles of the thigh, which enables us to rise or to leap. We have a mechanism of precisely the same kind in the lesser joints, where the bones, answering the purposes of the patella, are formed of a diminutive size.* In the toes of the ostrich the material is different, but the mechanism is the same. An elastic cushion is placed between the tendon and the joint, which, whilst it throws off the tendon from the centre of motion, and therefore adds to the power of the flexor muscle, gives elasticity to the bottom of the foot. And we recognize the intention of this when we remember that this bird does not fly, but runs with great swiftness, and that the whole weight rests upon the foot, which has but little relative breadth; these elastic cushions serving in some degree the same office as the elastic frog of the horse's hoof, or the cushion in the bottom of the camel's foot.

The web-foot of a water-fowl is an inimitable paddle; and all the ingenuity of the present day exerted to improve our steam-boats makes nothing to approach it. The flexor tendon of the toes of the duck is so directed over the heads of the bones of the thigh and leg, that it is made tight when the creature bends its

* Hence called *Sesamoid*, from *Sesamum*, a kind of grain.

leg, and is relaxed when the leg is stretched out. When the bird draws its foot up, the toes are drawn together, in consequence of the bent position of the bones of the leg pressing on the tendon. When, on the contrary, it pushes the leg out straight, in making the stroke, the tendons are relieved from the pressure of the heel-bone, and the toes are permitted to be fully extended and at the same time expanded, so that the web between them meets the resistance of a large volume of water.

In another class of birds, those which roost upon the branch of a tree, the same mechanism answers another purpose. The great length of the toes of these birds enables them to grasp the branch; yet were they supported by voluntary effort alone, and were there no other provision made, their grasp would relax in sleep, and they must fall. But, on the contrary, we know that they roost on one foot, and maintain a firm attitude. Borelli has taken pains to explain how this is. The muscle which bends the toes lies on the fore part of the thigh, and runs over the joint which corresponds with our knee-joint; from the fore part its tendon passes to the back part of the leg, and over the joint equivalent to our heel-bone; it then splits, and extends in the bottom of the foot to the toes. The consequence of this singular course of the tendon is, that when the mere weight of the bird causes these two joints to bend under it, the tendon is stretched, or would be stretched, were it not that its divided extremities, inserted into the last bones of the toes, draw those toes, so that they contract, and grasp the branch on which the bird roosts, without any effort whatever on its part.

These are facts learnt by induction; the inductive science of dynamics shows us that such mechanism is calculated to answer the end which, in point of fact, is attained. To conclude from thence that the mechanist contrived the means with the intention of producing this end, and with the knowledge of the science, is also strictly an inference of induction.

Consider now, in land animals, the structure of the larynx, the upper part of which is so contrived as to keep the windpipe closely shut by the valve thrown over its orifice, while the food is passing into the stomach, as it were, over a drawbridge, and, but for that valve, would fall into the lungs. No one can hesitate in ascribing this curious mechanism to the intention that the same opening of the throat and mouth should serve for conveying food to the stomach and air to the lungs, without any interference of the two operations. But that structure would not be sufficient for animals which live in the water, and must, therefore, while they breathe at the surface, carry down their food to devour it below. In them, accordingly, as in the whale and the porpoise, we find the valve is not flat, but prominent and somewhat conical, rising towards the back of the nose, and the continuation of the nostril by means of a ring (or *sphyncter*) muscle embraces the top of the windpipe so as to complete the communication between the lungs and the blow-hole, while it cuts off all communication between those lungs and the mouth.

Again, if we examine the structure of a porpoise's head, we find its cavities capable of great distention, and such that he can fill them at pleasure with air or with water, according as he would mount, float, or sink. By closing the blow-hole, he shuts out the water; by letting in the water he can sink; by blowing from the lungs against the cavities he can force out the water and fill the hollows with air, in order to rise. No one can doubt that such facts afford direct evidence of an apt contrivance directed towards a specific object, and adopted by some power thoroughly acquainted with the laws of hydrostatics, as well as perfectly skilful in workmanship.

To draw an example from a very different source, let us observe the structure of the planetary system. There is one particular arrangement which produces a certain effect—namely, the stability of the system,—produces it in a manner peculiarly adapted for perpetual duration, and produces it through the agency of an influence quite universal, pervading all space, and equally regulating the motions of the smallest particles of matter and of its most prodigious masses. This arrangement consists in making the planets move in orbits more or less elliptical, but none differing materially from circles, with the sun near the centre, revolving almost in one plane of motion, and moving in the same direction—those whose eccentricity is the most considerable having the smallest masses, and the larger ones deviating hardly at all from the circular path. The influence of gravitation, which is inseparably connected with all matter as far as we know, extends over the whole of this system; so that all those bodies which move round the sun—twenty-three planets including their satellites, and six or seven comets—are continually acted upon each by two kinds of force,—the original projection which sends them forward, and is accompanied with a similar and probably a coeval rotatory motion in some of them round their axis, and the attraction of each towards every other body, which attraction produces three several effects—consolidating the mass of each, and, in conjunction with the rotatory motion, moulding their forms—retaining each planet in its orbit round the sun, and each satellite in its orbit round the planet—altering or disturbing what would be the motion of each round the sun if there were no other bodies in the system to attract and disturb. Now it is demonstrated by the strictest process of mathematical reasoning, that the result of the whole of these mutual actions, proceeding from the universal influence of gravitation, must necessarily, in consequence of the peculiar arrangement which has been described of the orbits and masses, and in consequence of the law by which gravitation acts, produce a constant alteration in the orbit of each body, which alteration goes on for thousands of years, very slowly making that orbit bulge, as it were, until it reaches a certain shape, when the alteration begins to take the opposite direction, and for an equal number of years goes on constantly, as it were, flattening the orbit, till it reaches a certain shape, when it stops, and then the bulging again begins; and that this alternate change of bulging and flattening must go on for ever by the same law, without ever exceeding on either side a certain point. All changes in the system are thus periodical, and its perpetual stability is completely secured. It is manifest that such an arrangement, so conducive to such a purpose, and so certainly accomplishing that purpose, could only have been made with the express design of attaining such an end—that some power exists capable of thus producing such wonderful order, so marvellous and wholly admirable a harmony, out of such numberless disturbances—and that this power was actuated by the intention of producing this effect.* The reasoning upon this subject, I have observed, is purely mathematical; but the facts respecting the system on which all that reasoning rests are known to us by induction alone: consequently the grand truth respecting the secular disturbance, or the periodicity of the changes in the system—that discovery which makes the glory of Lagrange and Laplace, and constitutes the triumph of the Integral Calculus, whereof it is the fruit, and of the most patient course of astronomical observation whereon

* Earum autem perennes cursus atque perpetui cum admirabili incredibilique constantiâ, declarant in his vim et mentem esse divinam, ut hæc ipsa qui non sentiat deorum vim habere, is nihil omnino sensurus esse videatur.—[But their course, everlasting and perpetual, performed with admirable and incredible constancy, declares the Divine force and mind, so that whosoever fails to perceive the power of the Deity in them should seem incapable of perceiving anything.]—*Cicero De Nat. Deo.* II. 21.

the analysis is grounded—may most justly be classed as a truth both of the Mixed Mathematics and of Natural Theology—for the theologian only adds a single short link to the chain of the physical astronomer's demonstration, in order to reach the great Artificer from the phenomena of his system.

But let us examine further this matter. The position which we reach by a strict process of induction, is common to Natural Philosophy and Natural Theology—namely, that a given organ performs a given function, or a given arrangement possesses a certain stability, by its adaptation to mechanical laws. I have said that the process of reasoning is short and easy, by which we arrive at the doctrine more peculiar to Natural Theology—namely, that some power acquainted with and acting upon the knowledge of those laws, fashioned the organ with the intention of having the function of vision performed, or constructed the system so that it might endure. Is not this last process as much one of strict induction as the other? It is plainly only a generalization of many particular facts; a reasoning from things known to things unknown; an inference of a new or unknown relation from other relations formerly observed and known. If, to take Dr. Paley's example, we pass over a common and strike the foot against a stone, we do not stop to ask who placed it there; but if we find that our foot has struck on a watch, we at once conclude that some mechanic made it, and that some one dropt it on the ground. Why do we draw this inference? Because all our former experience had told us that such machinery is the result of human skill and labour, and that it nowhere grows wild about, or is found in the earth. When we see that a certain effect, namely, distinct vision, is performed by an achromatic instrument, the eye, why do we infer that some one must have made it? Because we nowhere and at no time have had any experience of any one thing fashioning itself, and indeed cannot form to ourselves any distinct idea of what such a process as self-creation means; and further, because when we ourselves would produce a similar result, we have recourse to like means. Again, when we perceive the adaptation of natural objects and operations to a perceived end, and from thence infer design in the maker of these objects and superintender of these operations, why do we draw this conclusion? Because we know by experience that if we ourselves desired to accomplish a similar purpose, we should do so by the like adaptation; we know by experience that this is design in us, and that our proceedings are the result of such design; we know that if some of our works were seen by others, who neither were aware of our having made them, nor of the intention with which we made them, they would be right should they, from seeing and examining them, both infer that we had made them, and conjecture why we had made them. The same reasoning, by the help of experience, from what we know to what we cannot know, is manifestly the foundation of the inference, that the members of the body were fashioned for certain uses by a maker acquainted with their operations, and willing that those uses should be served.

Let us consider a branch of science which, if not wholly of modern introduction, has received of late years such vast additions that it may really be said to have its rise in our own times—I allude to the sublime speculations in Osteology prosecuted by Cuvier, Buckland, and others, in its connection with Zoological and Geological researches.

A comparative anatomist, of profound learning and marvellous sagacity, has presented to him what to common eyes would seem a piece of half-decayed bone, found in a wild, in a forest, or in a cave. By accurately examining its shape, particularly the form of its extremity or extremities (if both ends happen to be entire), by close inspection of the texture of its surface, and by admeasurement of its proportions, he can with certainty discover the general form of the animal to which it belonged, its size as well as its shape, the economy of its viscera, and its general habits. Sometimes the investigation in such cases proceeds upon chains of reasoning where all the links are seen and understood; where the connection of the parts found with other parts and with habitudes is perceived, and the reason understood, — as that the animal had a trunk because the neck was short compared with its height; or that it ruminated because its teeth were imperfect for complete mastication. But, frequently, the inquiry is as certain in its results, although some links of the chain are concealed from our view, and the conclusion wears a more empirical aspect — as gathering that the animal ruminated from observing the print of a cloven foot, or that he had horns from his wanting certain teeth, or that he wanted the collar-bone from his having cloven hoofs. Limited experience having already shown such connexions as facts, more extended experience will assuredly one day enable us to comprehend the reason of the connexion.

The discoveries already made in this branch of science are truly wonderful, and they proceed upon the strictest rules of induction. It is shown that animals formerly existed on the globe, being unknown varieties of *species* still known; but it also appears that *species* existed, and even *genera*, wholly unknown for the last five thousand years. These peopled the earth, as it was, not before the general deluge, but before some convulsion long prior to that event had overwhelmed the countries then dry, and raised others from the bottom of the sea. In these curious inquiries, we are conversant not merely with the world before the flood, but with a world which, before the flood, was covered with water, and which, in far earlier ages, had been the habitation of birds, and beasts, and reptiles. We are carried, as it were, several worlds back, and we reach a period when all was water, and slime, and mud; and the waste, without either man or plants, gave resting place to enormous beasts like elephants and river-horses, while the water was tenanted by lizards, sixty or seventy feet long, and by others with eyes having shields of solid bone to protect them, and glaring from a neck ten feet in length, and the air was darkened by flying reptiles covered with scales, opening long jaws, and expanding wings armed at the tips with claws.

No less strange, and yet no less proceeding from induction, are the discoveries made respecting the former state of the earth; the manner in which those animals, whether of known or unknown tribes, occupied it; and the period when, or, at least, the way in which, they ceased to exist. Professor Buckland has demonstrated the identity with the hyæna's of the animal's habits that cracked the bones which fill some of the caves, in order to come at the marrow; but he has also satisfactorily shown that it inhabited the neighbourhood, and must have been suddenly exterminated by drowning. His researches have been conducted by experiments with living animals, as well as by observation upon the fossil remains.*

That this branch of scientific inquiry is singularly attractive all will allow. Nor will any one dispute that

* The researches both of Cuvier and Buckland, far from impugning the testimony to the great fact of a deluge borne by the Mosaic writings, rather fortify it; and bring additional proofs of the fallacy which, for some time, had led philosophers to ascribe a very high antiquity to the world we now live in.

The extraordinary sagacity of Cuvier is, perhaps, in no instance more shown, nor the singular nature of the science better illustrated, than in the correction which it enabled him to give the speculation of President Jefferson upon the *Megalonyx*—an animal which the President, from the size of a bone discovered, supposed to have existed, four times the size of an ox, and with the form and habits of the lion. Cuvier has irrefragably shown, by an acute and learned induction, that the animal was a sloth, living entirely upon vegetable food, but of enormous size, like a rhinoceros, and whose paws could tear up huge trees.

its cultivation demands great knowledge and skill. But this is not our chief purpose in referring to it. We learn from it that as a world existed without human beings, for no human bones are found in the earlier strata, it must be true that a superior power, a divine and creative power, interfered with the established order of things, and made man. But for another reason I have introduced these details. There can be as little doubt that the investigation of the former world from its scanty remains, forms, in the strictest sense of the term, a branch of physical science, and that this branch sprang legitimately from the grand root of the whole,—induction; in a word, that the process of reasoning employed to investigate — the kind of evidence used to demonstrate—its truths, is the modern analysis or induction taught by Bacon and practised by Newton. Now wherein, with reference to its nature and foundations, does it vary from the inquiries and illustrations of Natural Theology, one of whose propositions I have given as a corollary from this science? When from examining a few bones, or it may be a single fragment of a bone, we infer that, in the wilds where we found it, there lived and ranged, some thousands of years ago, an animal wholly different from any we ever saw, and from any of which any account, any tradition, written or oral, has reached us, nay, from any that ever was seen by any person of whose existence we ever heard, we assuredly are led to this remote conclusion, by a strict and rigorous process of reasoning; but, as certainly, we come through that same process to the knowledge and belief of things unseen, both of us and of all men—things respecting which we have not, and cannot have, a single particle of evidence, either by sense or by testimony. Yet we harbour no doubt of the fact in fossil osteology; we go farther, and not only implicitly believe the existence of this creature, for which we are forced to invent a name, but we clothe it with attributes, till, reasoning step by step, we come at so accurate a notion of its form and habits, that we can represent the one, and describe the other, with unerring accuracy; picturing to ourselves how it looked, what it fed on, and how it continued its kind.

Now, the question is this: What perceivable difference is there between the kind of investigations we have just been considering, and those of Natural Theology—except, indeed, that the latter are far more sublime in themselves, and incomparably more interesting to us? Where is the logical precision of the arrangement which would draw a broad line of demarcation between the two speculations, giving to the one the name and the rank of a science, but refusing it to the other, and affirming that the one rested upon induction, but not the other? We have, it is true, no experience directly of that Great Being's existence in whom we believe as our Creator; nor have we the testimony of any man relating such experience of his own. But so, neither we, nor any witnesses in any age, have ever seen those works of that Being, the lost animals that once peopled the earth; and yet the lights of inductive science have conducted us to a full knowledge of their nature, as well as a perfect belief in their existence. Without any evidence from our senses, or from the testimony of eye-witnesses, we believe in the existence and qualities of those animals, because we infer by the induction of facts that they once lived, and were endowed with a certain nature. This is called a doctrine of inductive philosophy. Is it less a doctrine of the same philosophy, that the eye could not have been made without a knowledge of optics, and as it could not make itself, and as no human artist, though possessed of the knowledge, has the skill and power to fashion it by his handy-work, that there must exist some being of knowledge, skill, and power, superior to our own, and sufficient to create it? Is the corollary which I have given from the proposition that these lost animals once existed before man was created, a corollary of Natural Theology, less the result of induction than that proposition itself a proposition of physical science? Has the Natural Theology any other foundation than the Natural Philosophy?

SECTION III.

COMPARISON OF THE PSYCHOLOGICAL BRANCH OF NATURAL THEOLOGY WITH PSYCHOLOGY.

HITHERTO, our argument has rested upon a comparison of the truths of Natural Theology with those of Physical Science. But the evidences of design presented by the universe are not merely those which the material world affords; the intellectual system is equally fruitful in proofs of an intelligent cause, although these have occupied little of the philosopher's attention, and may, indeed, be said never to have found a place among the speculations of the Natural Theologian. Nothing is more remarkable than the care with which all the writers upon this subject, at least among the moderns, have confined themselves to the proofs afforded by the visible and sensible works of nature, while the evidence furnished by the mind and its operations has been wholly neglected.* The celebrated book of Ray on the Wonders of the Creation seems to assume that the human soul has no separate existence—that it forms no part of the created system. Derham has written upon Astro-theology and Physico-theology as if the heavens *alone* proclaimed the glory of God, and the earth *only* showed forth his handy-work; for his only mention of intellectual nature is in the single chapter of the Physico-theology on the soul, in which he is content with two observations: one, on the variety of man's inclinations, and another, on his inventive powers—giving nothing which precisely proves design. Dr. Paley, whose work is chiefly taken from the writings of

* Note II.

Derham, deriving from them its whole plan and much of its substance, but clothing the harsher statements of his original in an attractive and popular style,* had so little of scientific habits, so moderate a power of generalizing, that he never once mentions the mind, or any of the intellectual phenomena, nor ever appears to consider them as forming a portion of the works or operations of nature. Thus, all these authors view the revolutions of the heavenly bodies, the structure of animals, the organization of plants, and the various operations of the material world which we see carried on around us, as indicating the existence of design, and leading to a knowledge of the Creator. But they pass over in silence, unaccountably enough, by far the most singular work of divine wisdom and power—the mind itself. Is there any reason whatever to draw this line; to narrow within these circles the field of Natural Theology; to draw from the constitution and habits of matter alone the proof that one Intelligent Cause formed and supports the universe? Ought we not rather to consider the phenomena of the mind as more peculiarly adapted to help this inquiry, and as bearing a nearer relation to the Great Intelligence which created and which maintains the system?

There cannot be a doubt that this extraordinary omission had its origin in the doubts which men are prone to entertain of the mind's existence independent of matter. The eminent persons above named† were

* This observation in nowise diminishes the peculiar merit of the style, and also of the homely, but close and logical, manner in which the argument is put; nor does it deny the praise of bringing down the facts of former writers, and adapting them to the improved state of physical science—a merit the more remarkable, that Paley wrote his Natural Theology at the close of his life.

† Some have thought, unjustly, that the language of Paley rather savours of materialism: but it may at least be doubted whether he was fully impressed with the evidence of mental existence. His unexercised powers of abstract discussion, and the natural predilection for what he handled so well—a practical argument level to all comprehensions—appear not to have given him any taste for metaphysical speculations.

not materialists, that is to say, if you had asked them the question, they would have answered in the negative; they would have gone farther, and asserted their belief in the separate existence of the soul independent of the body. But they never felt this as strongly as they were persuaded of the natural world's existence. Their habits of thinking led them to consider matter as the only certain existence—as that which composed the universe—as alone forming the subject of our contemplations—as furnishing the only materials for our inquiries, whether respecting structure or habits and operations. They had no firm, definite, abiding, precise idea of any other existence respecting which they could reason and speculate. They saw and they felt external objects; they could examine the lenses of the eye, the valves of the veins, the ligaments and the sockets of the joints, the bones and the drum of the ear; but though they now and then made mention of the mind, and, if forced to the point, would have acknowledged a belief in it, they never were fully and intimately persuaded of its separate existence. They thought of it and of matter very differently; they gave *its* structure, and *its* habits, and *its* operations, no place in their inquiries; their contemplations never rested upon it with any steadiness, and indeed scarcely ever even glanced upon it at all. That this is a very great omission, proceeding, if not upon mere carelessness, upon a grievous fallacy, there can be no doubt whatever.

The evidence for the existence of mind is to the full as complete as that upon which we believe in the existence of matter. Indeed it is more certain and more irrefragable. The consciousness of existence, the perpetual sense that we are thinking, and that we are performing the operation quite independently of all material objects, proves to us the existence of a being different from our bodies, with a degree of evidence higher than any we can have for the existence of those bodies themselves, or of any other part of the material world. It is certain—proved, indeed, to demonstration—that many of the perceptions of matter which we derive through the senses are deceitful, and seem to indicate that which has no reality at all. Some inferences which we draw respecting it are confounded with direct sensation or perception, for example, the idea of motion; other ideas, as those of hardness and solidity, are equally the result of reasoning, and often mislead. Thus we never doubt, on the testimony of our senses, that the parts of matter touch—that different bodies come in contact with one another, and with our organs of sense; and yet nothing is more certain than that there still is some small distance between the bodies which we think we perceive to touch. Indeed it is barely possible that all the sensations and perceptions which we have of the material world may be only ideas in our own minds: it is barely possible, therefore, that matter should have no existence. But that mind—that the sentient principle—that the thing or the being which we call "*I*" and "*we*," and which thinks, feels, reasons—should have no existence, is a contradiction in terms. Of the two existences, then, that of mind as independent of matter is more certain than that of matter apart from mind. In a subsequent branch of this discourse* we shall have occasion to treat again of this question, when the constitution of the soul with reference to its future existence becomes the subject of discussion. At present we have only to keep steadily in view the undoubted fact, that mind is quite as much an integral part of the universe as matter.

It follows that the constitution and functions of the mind are as much the subjects of inductive reasoning and investigation as the structure and actions of matter. The mind, equally with matter, is the proper subject of observation by means of consciousness, which enables

* Sec. V. and Note IV.

us to arrest and examine our own thoughts: it is even the subject of experiment, by the power which we have, through the efforts of abstraction and attention, of turning those thoughts into courses not natural to them, not spontaneous, and watching the results.* Now the phenomena of mind, at the knowledge of which we arrive by this inductive process, the only legitimate intellectual philosophy, afford as decisive proofs of design as do the phenomena of matter, and they furnish those proofs by the strict method of induction. In other words, we study the nature and operations of the mind, and gather from them evidences of design, by one and the same species of reasoning, the induction of facts. A few illustrations of these positions may be useful, because this branch of the science has, as we have seen, been unaccountably neglected by philosophers and theologians.

First. The structure of the mind, in every way in which we can regard it, affords evidences of the most skilful contrivance. All that adapts it so admirably to the operations which it performs, all its faculties, are plainly means working to an end. Among the most remarkable of these is the power of *reasoning*, or first comparing ideas and drawing conclusions from the comparison, and then comparing together those conclusions or judgments. In this process the great instrument is *attention*, as indeed it is the most important of all the mental faculties. It is the power by which the mind fixes itself upon a subject, and its operations are facilitated by many contrivances of nature, without which the effort would be painful, if not impossible—voluntary attention being the most difficult of all acts of the understanding.

Observe, then, in the *second* place, the helps which are provided for the exertion of this faculty. *Curiosity*, or the thirst of knowledge, is one of the chief of these.

* An instance will occur in the *Fifth* Section of this Part, in which experiments upon the course of our thoughts in sleep are described.

This desire renders any new idea the source of attraction, and makes the mind almost involuntarily, and with gratification rather than pain, bend and apply itself to whatever has the quality of novelty to rouse it. But *association* gives additional facilities of the same kind, and makes us attend with satisfaction to ideas which formerly were present and familiar, and the revival of which gives pleasure oftentimes as sensible as that of novelty, though of an opposite kind. Then, again, *habit*, in this, as in all other operations of our faculties, has the most powerful influence, and enables us to undergo intellectual labour with ease and comfort.

Thirdly. Consider the phenomena of *memory*. This important faculty, without which no intellectual progress whatever could be made, is singularly adapted to its uses. The tenacity of our recollection is in proportion to the attention which has been exercised upon the several objects of contemplation at the time they were submitted to the mind. Hence it follows, that by exerting a more vigorous attention, by detaining ideas for some time under our view, as it were, while they pass through the mind or before it, we cause them to make a deeper impression upon the memory, and are thus enabled to recollect those things the longest which we most desire to keep in mind. Hence, too, whatever facilitates attention, whatever excites it, helps the memory, as we sometimes say; so that we recollect those things the longest which were most striking at the time. But those things are, generally speaking, most striking, and most excite the attention, which are in themselves most important. In proportion, therefore, as anything is most useful or for any reason most desirable to be remembered, it is most easily stored up in our memory.

We may observe, however, in the *fourth* place, that readiness of memory is almost as useful as tenacity—quickness of bringing out as power of retention. *Habit* enables us to tax our recollection with surprising facility and certainty; as any one must be aware who has remarked the extraordinary feats performed by boys trained to learn things by heart, and especially to recollect numbers in calculating. From the same force of habit we derive the important power of forming artificial or conventional associations between ideas—of tacking, as it were, one to the other, in order to have them more under our control; and hence the relation between arbitrary signs and the things signified, and the whole use of language, whether ordinary or algebraical: hence, too, the formation of what is called artificial memory, and of all the other helps to recollection. But a help is provided for quickness of memory, independent of any habit or training, in what may be termed the natural association of ideas, whereby one thing suggests another from various relations of likeness, contrast, contiguity, and so forth. The same association of ideas is of constant use in the exercise of the inventive faculty, which mainly depends upon it, and which is the great instrument not only in works of imagination, but in conducting all processes of original investigation by pure reasoning.

Fifthly. The effect of *habit* upon our whole intellectual system deserves to be further considered, though we have already adverted to it. It is a law of our nature that any exertion becomes more easy the more frequently it is repeated. This might have been otherwise: it might have been just the contrary, so that each successive operation should have been more difficult; and it is needless to dwell upon the slowness of our progress, as well as the painfulness of all our exertions, say, rather, the impossibility of our making any advances in learning, which must have been the result of such an intellectual conformation. But the influence of habit upon the exercise of all our faculties is valuable beyond expression. It is indeed the great means of our improvement, both intellectual and moral, and it furnishes us with the chief, almost the only power we possess of making the different faculties of the mind obedient to the will. Whoever has observed the extraordinary feats performed by calculators, orators, rhymers, musicians, nay, by artists of all descriptions, can want no further proof of the power that man derives from the contrivances by which habits are formed in all mental exertions. The performances of the Italian *Improvvisatori*, or makers of poetry off-hand upon any presented subject and in almost any kind of stanza, are generally cited as the most surprising efforts in this kind. But the power of *extempore speaking* is not less singular, though more frequently displayed, at least in this country. A practised orator will declaim in measured and in various periods—will weave his discourse into one texture—form parenthesis within parenthesis—excite the passions, or move to laughter—take a turn in his discourse from an accidental interruption, making it the topic of his rhetoric for five minutes to come, and pursuing in like manner the new illustrations to which it gives rise—mould his diction with a view to attain or to shun an epigrammatic point, or an alliteration, or a discord; and all this with so much assured reliance on his own powers, and with such perfect ease to himself, that he shall even plan the next sentence while he is pronouncing off-hand the one he is engaged with, adapting each to the other, and shall look forward to the topic which is to follow, and fit in the close of the one he is handling to be its introducer; nor shall any auditor be able to discover the least difference between all this and the portion of his speech which he has got by heart, or mark the transition from the one to the other.*

Sixth. The feelings and the passions with which we are moved or agitated are devised for purposes apparent enough, and to effect which their adaptation

* This experiment has been tried with perfect success to my knowledge.

is undeniable. That of *love* tends to the continuance of the species—the *affections*, to the rearing of the young; and the former is fitted to the difference of sex, as the latter are to that of age. Generally, there are feelings of *sympathy* excited by distress and by weakness, and these beget attachment towards their objects, and a disposition to relieve them or to support. Both individuals and societies at large gain by the effects thence arising of union and connexion, and mutual help. So *hope*, of which the seeds are indigenous in all bosoms, and which springs up like certain plants in the soil as often as it is allowed to repose, encourages all our labours, and sustains us in every vicissitude of fortune, as well as under all the toils of our being. *Fear*, again, is the teacher of caution, prudence, circumspection, and preserves us from danger. Even *anger*, generally so painful, is not without its use: for it stimulates to defence, and it oftentimes assuages the pain given to our more tender feelings by the harshness, or ingratitude, or injustice, or treachery of those upon whom our claims were the strongest, and whose cruelty or whose baseness would enter like steel into the soul, were no re-action excited to deaden and to protect it. *Contempt*, or even *pity*, is calculated to exercise the same healing influence.* The operation of these reagents, so to speak, resembles the *vis medicatrix* in our bodily system, the form it has of throwing off foreign matter, or of healing injuries sustained. Then, to go no farther, *curiosity* is implanted in all minds to a greater or a less degree; it is proportioned to the novelty of objects, and consequently to our igno-

* "Atque illi (Crantor et Panætius) quidem etiam utiliter a naturâ dicebant permotiones istas animis nostris datas, metum cavendi causâ; misericordiam ægritudinemque clementiæ; ipsam iracundiam fortitudinis quasi cotem esse dicebant."—["And, indeed, these philosophers (Crantor and Panætius) held that such emotions were usefully implanted in our minds by Nature; fear for giving caution, pity and suffering for giving clemency; anger itself they maintained to be, as it were, the whetstone of fortitude."]—*Acad. Quæst.* iv. 44.

rance, and its immediate effects are to fix our attention —to stimulate our apprehensive powers—by deepening the impressions of all ideas on our minds, to give the memory a hold over them—to make all intellectual exertion easy, and convert into a pleasure the toil that would otherwise be a pain, Can anything be more perfectly contrived as an instrument of instruction, and an instrument precisely adapted to the want of knowledge, by being more powerful in proportion to the ignorance in which we are? Hence it is the great means by which, above all in early infancy, we are taught everything most necessary for our physical as well as moral existence. In riper years it smooths the way for further acquirements to most men; to some in whom it is strongest, it opens the paths of science; but in all, without any exception, it prevails at the beginning of life so powerfully as to make them learn the faculties of their own bodies, and the general properties of those around them—an amount of knowledge which, for its extent and its practical usefulness, very far exceeds, though the most ignorant possess it, whatever additions the greatest philosophers are enabled to build upon it in the longest course of the most successful investigations.

Nor is it the curiosity natural to us all that alone tends to the acquirement of knowledge; the *desire of communicating* it is a strong propensity of our nature, and conduces to the same important end. There is a positive pleasure as well in teaching others what they knew not before, as in learning what we did not know ourselves; and it is undeniable that all this might have been differently arranged without a material alteration of our intellectual and moral constitution in other respects. The propensity might have been, like the perverted desires of the miser, to retain what we know without communication, as it might have been made painful instead of pleasurable to acquire new ideas, by novelty being rendered repulsive and not agreeable.

The stagnation of our faculties, the suspension of mental exertion, the obscuration of the intellectual world, would have then followed as certainly as universal darkness would veil the universe on the extinction of the sun.

Thus far we have been considering the uses to which the mental faculties and feelings are subservient, and their admirable adaptation to these ends. But view the intellectual world as a whole, and surely it is impossible to contemplate without amazement the extraordinary spectacle which the mind of man displays, and the immense progress which it has been able to make in consequence of its structure, its capacity and its propensities, such as we have just been describing them. If the brightness of the heavenly bodies, the prodigious velocity of their motions, their vast distances and mighty bulk, fill the imagination with awe, there is the same wonder excited by the brilliancy of the intellectual powers—the inconceivable swiftness of thought—the boundless range which our fancy can take—the vast objects which our reason can embrace. That we should have been able to resolve the elements into their more simple constituents—to analyze the subtle light which fills all space—to penetrate from that remote particle in the universe, of which we occupy a speck, into regions infinitely remote—ascertain the weight of bodies at the surface of the most distant worlds—investigate the laws that govern their motions, or mould their forms—and calculate to a second of time the periods of their reappearance during the revolution of centuries,—all this is in the last degree amazing, and affords much more food for admiration than any of the phenomena of the material creation. Then what shall we say of that incredible power of generalization which has enabled some even to anticipate by ages the discovery of truths the farthest removed above ordinary apprehension, and the most savouring of improbability and fiction—not merely of a Clairaut conjecturing the existence of a seventh planet, and the position of its orbit, but of a Newton learnedly and sagaciously inferring, from the refraction of light, the inflammable quality of the diamond, the composition of apparently the simplest of the elements, and the opposite nature of the two ingredients, unknown for a century after, of which it is composed?* Yet there is something more marvellous still in the processes of thought, by which such prodigies have been performed, and in the force of the mind itself, when it acts wholly without external aid, borrowing nothing whatever from matter, and relying on its own powers alone. The most abstruse investigations of the mathematician are conducted without any regard to sensible objects; and the helps he derives in his reasonings from material things at all, are absolutely insignificant, compared with the portion of his work which is altogether of an abstract kind—the aid of figures and letters being only to facilitate and abridge his labour, and not at all essential to his progress. Nay, strictly speaking, there are no truths in the whole range of the pure mathematics which might not, by possibility, have been discovered and systematized by one deprived of sight and touch, or immured in a dark chamber, without the use of a single material object. The instrument of Newton's most sublime speculations, the *calculus* which he invented, and the astonishing systems reared by its means, which have given immortality to the names of Euler, Lagrange, Laplace, all are the creatures of pure abstract thought, and all might, by possibility, have existed in their present magnificence and splendour, without owing to material agency any help whatever, except such as might be necessary for their recording and communication. These are, surely, the greatest

* Further induction may add, to the list of these wonderful conjectures, the thin ether, of which he even calculated the density and the effects upon planetary motion. Certainly the acceleration of Encke's comet does seem to render the existence of some such medium by no means improbable.

of all the wonders of nature, when justly considered, although they speak to the understanding and not to the sense. Shall we, then, deny that the eye could be made without skill in optics, and yet admit that the mind could be fashioned and endowed without the most exquisite of all skill, or could proceed from any but an intellect of infinite power?

At first sight, it may be deemed that there is an essential difference between the evidence from mental and from physical phenomena. It may be thought that mind is of a nature more removed beyond our power than matter—that over the masses of matter man can himself exercise some control—that, to a certain degree, he has a plastic power—that into some forms he can mould them, and can combine into a certain machinery—that he can begin and can continue motion, and can produce a mechanism by which it may be begun, and maintained, and regulated—while mind, it may be supposed, is wholly beyond his reach; over it he has no grasp; its existence alone is known to him, and the laws by which it is regulated;—and thus, it may be said, the great First Cause, which alone can call both matter and mind into existence, has alone the power of modulating intellectual nature. But, when the subject is well considered, this difference between the two branches of science disappears with all the rest. It is admitted, of course, that we can no more create matter than we can mind; and we can influence mind in a way altogether analogous to our power of modulating matter. By means of the properties of matter we can form instruments, machines, and figures. So by availing ourselves of the properties of mind, we can affect the intellectual faculties—exercising them, training them, improving them, producing, as it were, new forms of the understanding. Nor is there a greater difference between the mass of rude iron from which we make steel, and the thousands of watch-springs into which that steel is cut, or the chronometer which we form of this and other masses equally inert—than there is between the untutored indocile faculties of a rustic who has grown up to manhood without education, and the skill of the artist who invented that chronometer, and of the mathematician who uses it to trace the motions of the heavenly bodies.

Although writers on Natural Theology have altogether neglected, at least in modern times, that branch of the subject at large with which we have now been occupied, there is one portion of it which has always attracted their attention — the *Instincts* of animals. These are unquestionably mental faculties, which we discover by observation and consciousness, but which are themselves wholly unconnected with any exercise of reason. They exhibit, however, the most striking proofs of design, for they all tend immediately to the preservation or to the comfort of the animals endowed with them. The lower animals are provided with a far greater variety of instincts, and of a more singular kind than man, because they have only the most circumscribed range and feeblest powers of reason, while to reason man is in almost everything indebted. Yet it would be as erroneous to deny that we are endowed with any instincts, because so much is accomplished by reason, as it would be rash to conclude that other animals are wholly destitute of reasoning, because they owe so much to instinct. Granting that infants learn almost all those animal functions which are of a voluntary nature, by an early exercise of reason, it is plain that instinct alone guides them in others which are necessary to continue their life, as well as to begin their instruction: for example, they suck, and even swallow by instinct, and by instinct they grasp what is presented to their hands. So, allowing that the brutes exercise but very rarely, and in a limited extent, the reasoning powers, it seems impossible to distinguish from the operations of reason those instances of sagacity which some dogs exhibit in obeying the directions of their master, and indeed generally the docility shown by them and other animals; not to mention the ingenuity of birds in breaking hard substances by letting them drop from a height, and in bringing the water of a deep pitcher nearer their beaks by throwing in pebbles. These are different from the operations of instinct, because they are acts which vary with circumstances novel and unexpectedly varying; they imply therefore the adaptation of means to an end, and the power of varying those means when obstacles arise: we can have no evidence of design, that is, of reason, in other men, which is not similar to the proof of reason in animals afforded by such facts as these.

But the operations of pure instinct, by far the greater portion of the exertions of brutes, have never been supposed by any one to result from reasoning, and certainly they do afford the most striking proofs of an intelligent cause, as well as of a unity of design in the world. The work of bees is among the most remarkable of all facts in both these respects. The form is in every country the same—the proportions accurately alike—the size the very same to the fraction of a line, go where you will; and the form is proved to be that which the most refined analysis has enabled mathematicians to discover as of all others the best adapted for the purposes of saving room, and work, and materials. This discovery was only made about a century ago; nay, the instrument that enabled us to find it out—the *fluxional* or *differential calculus* —was unknown half a century before that application of its powers. And yet the bee had been for thousands of years, in all countries, unerringly working according to this fixed rule, choosing the same exact angle of 120 degrees for the inclination of the sides of its little room, which every one had for ages known to be the best possible angle, but also choosing the same exact angles of 110 and 70 degrees for the parallelograms of the roof, which no one had ever discovered till the 18th century, when Kœnig solved that most curious problem of *maxima* and *minima*, the means of investigating which had not existed till the century before, when Newton and Leibnitz invented the *calculus*, whereby such problems can now be easily worked. It is impossible to conceive anything more striking as a proof of refined skill than the creation of such instincts, and it is a skill altogether applied to the formation of intellectual existence.*

Now, all the inferences drawn from the examination which we have just gone through of psychological phenomena are drawn according to the strict rules of inductive science. The facts relating to the velocity of mental operations—to the exercise of attention—to its connexion with memory—to the helps derived from curiosity and from habit—to the association of ideas—to the desires, feelings, and passions—and to the adjoining provinces of reason and instinct—are all discovered by consciousness or by observation; and we even can make experiments upon the subject by varying the circumstances in which the mental powers are exercised by ourselves and others, and marking the results. The facts thus collected and compared together we are enabled to generalize, and thus to show that certain effects are produced by an agency calculated to produce them. Aware that if we desired to produce them, and had the power to employ this agency, we should resort to it for accomplishing our purpose, we infer both that some being exists capable of creating this agency, and that he employs it for this end. The process of reasoning is not like, but identical with, that by which we infer the existence of design in others (than ourselves) with whom we have daily intercourse. The kind of evidence is not like, but identical with, that by which we conduct all the investigations of intellectual and of natural science.

* See *Dialogues on Instinct*, where the subject of the Bee-architecture is more fully treated.

Such is the process of reasoning by which we infer the existence of design in the natural and moral world. To this abstract argument an addition of great importance remains to be made. The whole reasoning proceeds necessarily upon the assumption that there exists a being or thing separate from, and independent of, matter, and conscious of its own existence, which we call *mind.* For the argument is—"Had I to accomplish this purpose, I should have used some such means;" or, "Had I used these means, I should have thought I was accomplishing some such purpose." Perceiving the adaptation of the means to the end, the inference is, that some being has acted as we should ourselves act, and with the same views. But when we so speak, and so reason, we are all the while referring to an intelligent principle or existence: we are referring to our mind, and not to our bodily frame. The agency which we infer from this reasoning is, therefore, a spiritual and immaterial agency—the working of something like our own mind—and intelligence like our own, though incomparably more powerful and more skilful. The Being of whom we thus acquire a knowledge, and whose operations as well as existence we thus deduce from a process of inductive reasoning, must be a spirit, and wholly immaterial. But his being such is only inferred, because we set out with assuming the separate existence of our own mind, independently of matter. Without that we never could conclude that superior *intelligence* existed or acted. The belief that mind exists is essential to the whole argument by which we infer that the Deity exists. This belief we have shown to be perfectly well grounded, and further occasions of confirming the truth of it will occur under another head of discourse.* But at any rate it is the foundation of Natural Theology in all its branches: and upon the scheme of materialism no rational, indeed no

* Sec. V. and Note IV.

intelligible, account can be given for a First Cause, or of the creation or government of the universe.*

The preceding observations have been directed to the inquiries respecting the design exhibited in the universe. But the other parts of the first great branch of Natural Theology come strictly within the scope of the same reasoning. Thus, all the proofs of the Deity's *personality*, that is, His individuality, His unity; all the evidence which we have of His works, showing throughout not only that they proceeded from design, but that the design is of one distinctive kind—that they come from the hand not only of an intelligent being, but of a being whose intellect is specifically peculiar, and always of the same character; all these proofs are in the most rigorous sense inductive.

* It is worthy of observation, that not the least illusion is made in Dr. Paley's work to the argument here stated, although it is the foundation of the whole of Natural Theology. Not only does this author leave entirely untouched the argument *à priori* (as it is called), and also all the inductive arguments derived from the phenomena of mind, but he does not even advert to the argument upon which the inference of design must of necessity rest—that design which is the whole subject of his book. Nothing can more evince his distaste or his inferior capacity for metaphysical researches. He assumes the very position which alone sceptics dispute. In combating him they would assert that he begged the whole question; for certainly they do not deny, at least in modern times, the *fact* of adaptation. As to the fundamental doctrine of causation, not the least allusion is ever made to it in any of his writings, even in his Moral Philosophy. This doctrine is discussed in Note III.

SECTION IV.

OF THE ARGUMENT À PRIORI.

Hitherto we have confined our attention to the evidences of Natural Religion afforded by the phenomena of the universe—what is commonly termed the argument *à posteriori*. But some ingenious men, conceiving that the existence and attributes of a Deity are discoverable by reasoning merely, and without reference to facts, have devised what they term the argument *à priori*, of which it is necessary now to speak.

The *first* thing that strikes us on this subject is the consequence which must inevitably follow from admitting the possibility of discerning the existence of the Deity and His attributes *à priori*, or wholly independent of facts. It would follow that this is a necessary, not a contingent truth, and that it is not only as impossible for the Deity not to exist, as for the whole to be greater than the sum of its parts, but that it is equally impossible for His attributes to be other than the argument is supposed to prove they are. Thus the reasoners in question show, by the argument *à priori*, that He is a being of perfect wisdom and perfect benevolence. Dr. Clarke is as clear of this as he is clear that His existence is proved by the same argument. Now, first, it is impossible that any such truths can be necessary; for their contraries are not things wholly inconceivable, inasmuch as there is nothing at all inconceivable in the Maker of the universe existing as a being of limited power and of mixed goodness, nay of malevolence. We never, before all experience, could pronounce it mathematically impossible that such a being should exist, and should have created the universe. But next, the facts, when we came to examine them, *might* disprove the conclusions drawn *à priori*. The universe *might* by possibility be so constructed that every contrivance might fail to produce the desired effect—the eye might be chromatic and give indistinct images—the joints might be so unhinged as to impede motion—every smell, as Paley has it, might be a taint, and every touch a sting. Indeed, we know that, perfect as the frame of things actually is, a few apparent exceptions to the general beauty of the system have made many disbelieve the perfect power and perfect goodness of the Deity, and invent Manichean theories to account for the existence of evil. Nothing can more clearly show the absurdity of those arguments by which it is attempted to demonstrate the truths of this science as mathematical or necessary, and cognizable *à priori*.

But, *secondly*, let us see whether the argument in question be really one *à priori*, or only a very imperfect process of induction—an induction from a limited number of facts.

Dr. Clarke is the chief patron of this kind of demonstration, as he terms it; and though his book contains it more at large, the statement of his fundamental argument is, perhaps, to be found most distinctly given in the letters subjoined to that celebrated work. The fundamental propositions in the discourse itself are, That something must have existed from all eternity, and that this something must have been a being independent and self-existent. In the letters he condenses, perhaps explains, certainly illustrates, these positions (see Answers to Letters 3, 4, and 5) by arguing that the existence of space and time (or, as he terms it, duration) proves the existence of something whereof these are qualities, for they are not themselves substances; he cites the celebrated *Scholium Generale* of the *Principia;* and he concludes that the Deity must be the infinite being of whom they are qualities.

But to argue from the existence of space and time to the existence of anything else, is assuming that those two things have a real being independent of our conceptions of them; for the existence of certain ideas in our minds cannot be the foundation on which to build a conclusion that anything external to our minds exists. To infer that space and time are qualities of an infinite and eternal being is surely assuming the very thing to be proved, if a proposition can be said to have a distinct meaning at all which predicates space and time as qualities of anything. What, for example, is time but the succession of ideas, and the consciousness and the recollection which we have of that succession? To call it a quality is absurd; as well might we call motion a quality, or our ideas of absent things and persons a quality.

Again, if space is to be deemed a quality, and if infinite space be the quality of an infinite being, finite space must also be a quality, and must, by parity of reason, be the quality of a finite being. Of what being? Here is a cube of one foot within an exhausted receiver, or a cylinder of half an inch diameter and three inches high in the Torricellian vacuum. What is the being of whom that square and that round space are to be deemed as qualities? Is distance, that is, the supposed movement of a point in a straight line, *ad infinitum*, a quality? It must be so if infinite space is. Then of what is it a quality? If infinite space is the quality of an infinite being, infinite distance must be the quality of an infinite being also. But can it be said to be the quality of the same infinite being? Observe that the mind can form just as correct an idea of infinite distance as of infinite space, or, rather, it can form a somewhat more distinct idea. But the being to be inferred from this infinite distance cannot be exactly the same in kind with that to be inferred from space infinite in all directions. Again, if infinite distance shows an infinite being of whom it is the quality, finite distance must be the quality of a finite being. What being? Of what kind of being is the distance between two trees or two points a quality? There can be no doubt that this argument rests either upon the use of words without meaning, or it is a disguised form of the old doctrine of the *anima mundi*, or of the hypothesis that the whole universe is a mere emanation of the Deity.

But it deserves to be remarked that this argument, which professes to be *à priori*, and wholly independent of all experience, is, strictly speaking, inductive, and nothing more. We can have no idea whatever of space apart from experience. The experience of space filled with matter enables us, by means of abstraction, to conceive space without the matter; and a further abstraction and generalization enable us to conceive infinite space by imagining the limits indefinitely removed of a particular portion of space. But the foundation of the whole reasoning is the experience of certain finite portions of space first observed in connexion with matter. Therefore our ideas of space are the result of our experience as to external objects. Even if we would fancy figure (which is possible) without having seen or touched any objects external to ourselves, still it would be the experience of our own ideas that had given us this idea. So of time; it is the succession of our ideas, and we have the notion of it from consciousness and memory. From hence we form an idea of indefinite time or eternal duration. But the basis of the whole is the observation which we have made upon the actual succession of our ideas; and this is inductive, though the process of reasoning be very short. It is as much a process of inductive reasoning as that by which we arrive at the knowledge of the mind's existence. There is, therefore, great inaccuracy in denominating the argument in question, were it ever so sound, an argument *à priori*, for it is a reasoning founded on experience, and it is to be classed with the arguments derived from the observation of external objects, the ground of our reasoning *à posteriori* as to matter, or, at the utmost, with the information given by consciousness, the whole ground of our reasoning *à posteriori* as to mind.

When, however, Dr. Clarke has once fixed the propositions to which we have been adverting, he deduces from them the whole qualities of the Deity—those which we learn from experience—and thinks he can derive them all from the simple propositions that lie at the foundation of his argument. It is truly astonishing to find so profound a thinker, and, generally speaking, so accurate a reasoner, actually supposing that he can deduce from the proposition, that a self-existent being must have existed from all time, this other proposition, that therefore this being must be infinitely wise (Prop. XI.), and that he "must of necessity be a being of infinite goodness, justice, and truth, and all other moral perfections, such as become the supreme *governor* and *judge* of the world." (Prop. XII.) With the general texture of this argument we have at present nothing to do, further than to show how little it can by possibility either deserve the name of an argument *à priori*, or be regarded as the demonstration of a necessary truth. For surely, prior to all experience, no one could ever know that there were such things as either judges or governors; and without the previous idea of a finite or worldly ruler and judge, we could never gain any idea of an eternal and infinitely just ruler or judge; and equally certain it is that this demonstration, if it proves the existence of an infinite and eternal ruler or judge to be a necessary and not a contingent truth (which is Dr. Clarke's whole argument), would just as strictly prove the existence of finite rulers and judges to be a necessary and not a contingent truth; or, in other words, it would follow, that the existence of governors and judges in the world is a necessary truth, like the equality of the three angles in a triangle to two right angles, and that it would be a contradiction in terms, and so an impossibility, to conceive the world existing without governors and judges.

I believe it may safely be said, that very few men have ever formed a distinct apprehension of the nature of Dr. Clarke's celebrated argument, and that hardly any person has ever been at all satisfied with it. The opinion of Dr. Reid is well known upon this subject, and it has received the full acquiescence of no less an authority than that of Mr. Stewart.

"These," says Dr. Reid, "are the speculations of men of superior genius; but whether they be as solid as they are sublime, or whether they be the wanderings of imagination in a region beyond the limits of human understanding, I am unable to determine."

To this Mr. Stewart adds—"After this candid acknowledgment from Dr. Reid, I need not be ashamed to confess my own doubts and difficulties on the same subject."*

That the argument *à priori* has been most explicitly handled by Dr. Clarke, and that its acceptation rests principally upon his high authority, cannot be denied. Nevertheless, other great men preceded him in this field; and beside Sir Isaac Newton's *Scholium Generale*, which is thought to have suggested it, the same reasoning is to be found in the writings of others of Dr. Clarke's predecessors.

The tenth chapter of Mr. Locke's fourth book does not materially differ, in its fundamental position, from the "Demonstration of the Being and Attributes." The argument is all drawn from the truth, assumed as self-evident. "Nothing can no more produce any real being than it can be equal to two right angles." From this, and the knowledge we have of our own existence, it is shown to follow, that, "from eternity there has been something;" and again, "that this eternal being must have been most powerful and most knowing," and

* Philosophy of the Active Powers, i. 334.

"therefore God." The only difference between this argument and Dr. Clarke's is, that Mr. Locke states, as one of his propositions, our knowledge of our own existence. But this difference is only in appearance; for Dr. Clarke really has assumed what Mr. Locke has more logically made a distinct proposition. Dr. Clarke's first proposition, that something must have existed from all eternity, is demonstrated by showing the absurdity of the supposition that "the things which now are were produced out of nothing." He therefore assumes the existence of those things, while Mr. Locke more strictly assumes the existence of ourselves only, and indeed states it as a proposition. The other arguments of Mr. Locke are more ingenious than Dr. Clarke's, and the whole reasoning is more rigorous, although he does not give it the name of a Demonstration, and scarcely can be said to treat it as proving that the Deity's existence is a necessary truth. Were it to be so considered, the objections formerly stated would apply to it. Indeed, if Dr. Clarke had stated the different steps of his reasoning as distinctly as Mr. Locke has done, he would have perceived it to be inconclusive beyond a very limited extent, and to that extent inductive.*

Dr. Cudworth, in the fifth chapter of his great work,† has, in answering the Democritick arguments, so plainly anticipated Dr. Clarke, that it is hardly possible to conceive how the latter should have avoided referring to the passage.‡ "If space be indeed a nature distinct from body, and a thing really incorporeal, then will it undeniably follow, from this very

* See particularly Mr. Locke's proofs of his first position.—*Hum. Understanding*, IV. x. sec. 2.

† *Intellectual System*, Book I. c. v. s. 3, par. 4. The profound learning of this unfinished work, and its satisfactory exposition of the ancient philosophers, are above all praise. Why are the manuscripts of the author still buried in the British Museum?

‡ Cudworth's book was published in 1678. The 'Demonstration' was delivered in 1704-5 at the Boyle Lecture.

principle of theirs (the Democritists), that there must be incorporeal space; and (this space being supposed by them also to be infinite) an infinite incorporeal Deity. Because if space be not the extension of body, nor an affection thereof, then must it of necessity be, either an accident existing alone by itself, without a substance, which is impossible; or else the extension or affection of some other incorporeal substance that is infinite." He then supposes a reply (founded on the doctrines of Gassendi), that space is of a middle nature and essence, and proceeds to observe upon it:—"Whatsoever is, or hath any kind of entity, doth either subsist by itself, or else is an attribute, affection, or mode of something that doth subsist by itself. For it is certain that there can be no mode, accident, or affection of nothing; and, consequently, that nothing cannot be extended nor mensurable. But if space be neither the extension of body, nor yet of substance incorporeal, then must it of necessity be the extension of nothing, and the affection of nothing, and nothing must be measurable by yards and poles. We conclude, therefore, that from this very hypothesis of the Democritick and Epicurean atheists, that space is a nature distinct from body, and positively infinite, it follows undeniably that there must be some incorporeal substance whose affection its extension is: and because there can be nothing infinite but only the Deity, that it is the infinite extension of our incorporeal Deity." The statement of Dr. Clarke's argument, given in his correspondence, is manifestly, if not taken from this, at least coincident with it in every important respect. Dr. Cudworth, indeed, confines his reasoning to the consideration of space and immensity, and Dr. Clarke extends his to time and eternity also. But of the two portions of the argument this has been shown to be the most fallacious.

The arguments of the ancient theists were in great part drawn from metaphysical speculations, some of which resembled the argument *à priori*.* But they were pressed by the difficulty of conceiving the possibility of creation, whether of matter or spirit; and their inaccurate views of physical science made them consider this difficulty as peculiar to the creative act. They were thus driven to the hypothesis that matter and mind are eternal, and that the creative power of the Deity is only plastic. They supposed it easy to comprehend how the divine mind should be eternal and self-existing, and matter also eternal and self-existing. They found no difficulty in comprehending how that mind could, by a wish or a word, reduce chaos to order, and mould all the elements of things into their present form; but how everything could be made out of nothing they could not understand. When rightly considered, however, there is no more difficulty in comprehending the one than the other operation—the existence of the plastic, than of the creative power; or rather, the one is as incomprehensible as the other. How the Supreme Being made matter out of the void is not easily comprehended. This must be admitted; but is it more easy to conceive how the same Being, by his mere will, moved and fashioned the primordial atoms of an eternally existing chaos into the beauty of the natural world, or the regularity of the solar system? In truth, these difficulties meet us at every step of the argument in Natural Theology, when we would penetrate beyond those things, those facts which our faculties can easily comprehend; but they meet us just as frequently, and are just as hard to surmount, in our steps over the field of Natural Philosophy. How matter acts on matter—how motion is begun, or, when begun, ceases—how impact takes place—what are the conditions and limitations of contact—whether or not matter consists of ultimate particles, endowed with opposite powers of attraction and repulsion, and

* Notes VI. and VII.

how these act—how one planet acts npon another at the distance of a hundred million of miles—or how one piece of iron attracts and repels another at a distance less than any visible space—all these, and a thousand others of the like sort, are questions just as easily put, and as hard to answer, as how the universe could be made out of nothing, or how, out of chaos, order could be made to spring.

In concluding these observations upon the argument *à priori*, I may remark, that although it carries us but a very little way, and would be unsafe to build upon alone, it is yet of eminent use in two particulars. First, it illustrates, if it does not indeed prove, the possibility of an Infinite Being existing beyond and independent of us and of all visible things; and, secondly, the fact of those ideas of immensity and eternity, forcing themselves, as Mr. Stewart expresses it, upon our belief, seems to furnish an additional argument for the existence of an immense and Eternal Being. At least we must admit that excellent person's remark to be well-founded, that after we have, by the argument *à posteriori* (I should rather say the *other parts* of the argument *à posteriori*), satisfied ourselves of the existence of an intelligent cause, we naturally connect with this cause those impressions which we have derived from the contemplation of infinite space and endless duration, and hence we clothe with the attributes of immensity and eternity the awful Being whose existence has been proved by a more rigorous process of investigation.*

* The late Earl Spencer, who had deeply studied these abstruse subjects, communicated to me, before he was aware of my opinion, that he had arrived at nearly the same conclusion upon the merits of the argument *à priori.*

SECTION V.

MORAL OR ETHICAL BRANCH OF NATURAL THEOLOGY.

If we now direct our attention to the other great branch of Natural Theology, that which we have termed the moral or ethical portion, which treats of the probable designs of the Deity with respect to the future destiny of his creatures, we shall find that the same argument applies to the nature of its truths which we have been illustrating in its application to the first or ontological branch of the science, or that relating to the existence and attributes of the Creator, whether proved by physical or by psychological reasoning. The second branch, like the first, rests upon the same foundation with all the other inductive sciences, the only difference being that the one belongs to the inductive science of Natural and Mental, and the other to the inductive science of Moral Philosophy.

The means which we have of investigating the probable designs of the Deity are derived from two sources —the nature of the human mind, and the attributes of the Creator.

To the consideration of these we now proceed; but in discussing them, and especially the first, there is this difference to be marked as distinguishing them from the former branch of Natural Theology. They are far less abundant in doctrine; they have been much less cultivated by scientific inquirers; and the truths ascertained in relation to them are fewer in number: in a word, our knowledge of the Creator's designs in the order of nature is much more limited than our acquaintance with his existence and attributes. But, on the other hand, the identity of the evidence with that on which the other inductive sciences rest is far more conspicuous in what may be termed the psychological part of the second branch of Natural Theology than in any portion of the first branch, it being much less apparent that the inferences drawn from facts in favour of the Deity's existence and attributes are of the same nature with the ordinary deductions of physical science—in other words, that this part of Natural Theology is a branch of Natural Philosophy—than it is that the deductions from the nature of the mind in favour of its separate and future existence are a branch of Metaphysical science.

From this diversity it follows, that, in treating this second branch of the subject, there will be more necessity for entering at large into the subject of the Deity's probable designs in regard to the soul, especially those to be inferred from its constitution, than we found there was for entering into the evidences of his existence and attributes, although there will not be so much labour required for proving that this is a branch of inductive science.

I. PSYCHOLOGICAL ARGUMENT, OR EVIDENCE OF THE DEITY'S DESIGNS DRAWN FROM THE NATURE OF THE MIND.

THE Immateriality of the Soul is the foundation of all the doctrines relating to its future State. If it consists of material parts, or if it consists of any modification of matter, or if it is inseparably connected with any combination of material elements, we have no reason whatever for believing that it can survive the existence of the physical part of our frame; on the contrary, its destruction seems to follow as a necessary consequence from the dissolution of the body. It is true that the body is not destroyed in the sense of being annihilated; but it is equally true that the particular conformation, the particular arrangement of material particles with which the soul is supposed to have been inseparably connected, or in which it is supposed to consist, is gone and destroyed even in the sense of annihilation; for that arrangement or conformation has no longer an existence, any more than a marble statue can be said to have an existence when it is burned into a mass of pounded quick-lime. Now it is to the particular conformation and arrangement, and not to the matter itself, that the soul is considered as belonging by any theory of materialism, there being none of the theories of materialists so absurd as to make the total mass of the particles themselves, independent of their arrangement, the seat of the soul. Therefore, the destruction of that form and organization as effectually destroys the soul which consists in it, as the beauty or the intellectual expression of the statue is gone when the marble is reduced to lime-dust.

Happily, however, the doctrines of materialism rest upon no solid foundation, either of reason or experience. The vague and indistinct form of the propositions in which they are conveyed affords one strong argument against their truth. It is not easy to annex a definite meaning to the proposition that mind is inseparably connected with a particular arrangement of the particles of matter; it is more difficult to say what they mean who vaguely call it a modification of matter; but to consider it as consisting in a combination of matter, as coming into existence the instant that the particles of matter assume a given arrangement, appears to be a wholly unintelligible collocation of words.

Let us, however, resort to experience, and inquire what results may be derived from that safe guide whom modern philosophers most willingly trust, though despised as too humble a helpmate by most of the ancient sages.

We may *first* of all observe that if a particular combination of matter gives birth to what we call mind, this is an *operation* altogether peculiar and unexampled. We have no other instance of it; we know of no case in which the combination of certain elements produces something quite different, not only from each of the simple ingredients, but also different from the whole compound. We can, by mixing an acid and an alkali, form a third body, having the qualities of neither, and possessing qualities of its own different from the properties of each; but here the third body consists of the other two in combination. There are not two things—two different existences—the neutral salt composed of the acid and the alkali, and another thing different from that neutral salt and engendered for the first time by that salt coming into existence. So when, by chiselling, "the marble softened into life grows warm," we have the marble new moulded, and endowed with the power of agreeably affecting our senses, our memory, and our fancy; but it is all the while the marble: there is the beautiful and expressive marble instead of the amorphous mass, and we have not, beside the marble, a new existence created by the form which has been given to that stone. But the materialists have to maintain that, by matter being arranged in a particular way, there is produced both the organized body and something different from it, and having not one of its properties—neither dimensions, nor weight, nor colour, nor form. They have to maintain that the chemist who mixed the aqua-fortis and potash produced both nitre and something quite different from all the three, and which began to exist the instant that the nitre crystallized; and that the sculptor who fashioned the Apollo, not only made the marble into a human figure, but called into being something different from the marble and the statue, and which exists at the same time with both and without one property of either. If, therefore, their theory is true, it must be admitted to rest upon nothing which experience has ever taught *us: it supposes* operations to be performed and relations to exist of which we see nothing that bears the least resemblance in anything we know.

But *secondly*, the doctrine of the materialists in every form which it assumes is contradicted by the most plain and certain deductions of experience. The evidence which we have of the existence of the mind is complete in itself, and wholly independent of the qualities or the existence of matter. It is not only as strong and conclusive as the evidence which makes us believe in the existence of matter, but more strong and more conclusive; the steps of the demonstration are fewer; the truth to which they conduct the reason is less remote from the axiom — the intuitive or self-evident position whence the demonstration springs. We believe that matter exists because it makes a certain impression upon our senses, that is, because it produces a certain change or a certain effect; and we argue, and argue justly, that this effect must have a cause, though the proof is by no means so clear that this cause is something external to ourselves. But we know the existence of mind by our consciousness of or reflection on what passes within us, and our own existence as sentient and thinking beings implies the existence of the mind which has sense and thought. To know, therefore, that we are, and that we think, implies a knowledge of the soul's existence. But this knowledge is altogether independent of matter, and the subject of it bears no resemblance whatever to matter in any one of its qualities, or habits, or modes of action. Nay, we only know the existence of matter through the operations of the mind; and were we to doubt of the existence of either, it would be far more reasonable to doubt that matter exists than that mind exists. The existence and the operations of mind, supposing it to exist, will account for all the phenomena which matter is supposed to exhibit. But the existence and action of matter, vary it how we may, will never account for one of the phenomena of mind.

We do not believe more firmly in the existence of the sensible objects around us when we are well and awake, than we do in the reality of those phantoms which the imagination conjures up in the hours of sleep, or the season of derangement. But no effect produced by material agency ever produced a spiritual existence, or engendered the belief of such an existence; indeed, the thing is almost a contradiction in terms. That all around us should only be the creatures of our fancy, no one can affirm to be impossible. But that our mind—that which remembers—compares—imagines—in a word, that which thinks—that of the existence of which we are perpetually conscious—that which cannot but exist if we exist—that which can make its own operations the subject of its own thoughts—that this should have no existence is both impossible and indeed a contradiction in terms. We have, therefore, evidence of the strictest kind—induction of facts the most precise and unerring—to justify the conclusion that the mind exists, and is different from and independent of matter altogether.*

Now this proposition not only destroys the doctrine of the materialists, but leads to the strongest inferences in favour of the mind surviving the body with which it is connected through life. All our experience shows no one instance of annihilation. Matter is perpetually changing—never destroyed; the form and manner of its existence are endlessly and ceaselessly varying—its existence never terminates. The body decays, and is said to perish; that is, it is resolved into its elements, and becomes the material of new combinations, animate and inanimate, but not a single particle of it is annihilated; nothing of us or around us ever ceases to exist. If the mind perishes, or ceases to exist at death, it is the only example of annihilation which we know.

But, it may be said, why should it not, like the

* See, on the Hypothesis of Materialism, Note IV.

body, be changed, or dissipated, or resolved into its elements? The answer is plain: it differs from the body in this, that it has no parts; it is absolutely one and simple; therefore it is incapable of resolution or dissolution. These words, and the operations or events they refer to, have no application to a simple and immaterial existence.

Indeed, our idea of annihilation is wholly derived from matter, and what we are wont to call destruction means only change of form and resolution into parts, or combination into new forms. But for the example of the changes undergone by matter, we should not even have any notion of destruction or annihilation. When we come to consider the thing itself, we cannot conceive it to be possible; we can well imagine a parcel of gunpowder or any other combustible substance ceasing to exist as such by burning or exploding; but that its whole elements should not continue to exist in a different state, and in new combinations, appears inconceivable. We cannot follow the process so far; we can form no conception of any one particle that once is, ceasing wholly to be. How then can we form any conception of the mind which we now know to exist ceasing to be? It is an idea altogether above our comprehension. True, we no longer, after the body is dissolved, perceive the mind, because we never knew it by the senses; we only were aware of its existence in others by its effects upon matter, and had no experience of it unconnected with the body. But it by no means follows that it should not exist, merely because we have ceased to perceive its effects upon any portion of matter. It had connexion with the matter which it used to act upon, and by which it used to be acted upon; when its entire severance took place that matter underwent a great change, but a change arising from its being of a composite nature. The same separation cannot have affected the mind in the like manner, because its nature is simple and not composite. Our ceasing to perceive any effects produced by it on any portion of matter, the only means we can have of ascertaining its existence, is therefore no proof that it does not still exist; and even if we admit that it no longer does produce any effect upon any portion of matter, still this will offer no proof that it has ceased to exist. Indeed, when we speak of its being annihilated, we may be said to use a word to which no precise meaning can be attached by our imaginations. At any rate it is much more difficult to suppose that this annihilation has taken place, and to conceive in what way it is effected, than to suppose that the mind continues in some state of separate existence, disencumbered of the body, and to conceive in what manner this separate existence is maintained.

It may be further observed that the material world affords no example of creation, any more than of annihilation. Such as it was in point of quantity since its existence began, such it still is, not a single particle of matter having been either added to it or taken from it. Change—unceasing change—in all its parts, at every instant of time, it is for ever undergoing; but though the combinations or relations of these parts are unremittingly varying, there has not been a single one of them created, or a single one destroyed. Of mind this cannot be said; it is called into existence perpetually before our eyes. In one respect this may weaken the argument for the continued existence of the soul, because it may lead to the conclusion, that as we see mind created, so may it be destroyed; while matter, which suffers no addition, is liable to no loss. Yet the argument seems to gain in another direction more force than it loses in this; for nothing can more strongly illustrate the diversity between mind and matter, or more strikingly show that the one is independent of the other.

Again, the mind's independence of matter and capacity of existence without it, appears to be strongly illustrated by whatever shows the entire dissimilarity of its constitution. The inconceivable rapidity of its operations is, perhaps, the most striking feature of the diversity; and there is no doubt that this rapidity increases in proportion as the interference of the senses —that is, the influence of the body—is withdrawn. A multitude of facts, chiefly drawn from and connected with the Phenomena of Dreams, throw a strong light upon this subject, and seem to demonstrate the possible disconnexion of mind and matter.

The bodily functions are in part suspended during sleep—that is, all those which depend upon volition. The senses, however, retain a portion of their acuteness; and those of touch* and hearing, especially, may be affected without awakening the sleeper. The consequence of the cessation which takes place of all communication of ideas through the senses is that the action of the mind, and, above all, of those powers connected with the imagination, becomes much more vigorous and uninterrupted. This is shown in two ways—first, by the celerity with which any impression upon the senses, strong enough to be felt without awakening, is caught up and made the groundwork of a new train of ideas, the mind instantly accommodating itself to the suggestions of the impression, and making all its thoughts chime in with that; and, secondly, by the prodigiously long succession of images that pass through the mind, with perfect distinctness and the greatest liveliness, in an instant of time.

The facts upon this subject are numerous, and of undeniable certainty, because of daily occurrence. Every one knows the effect of a bottle of hot water applied during sleep to the soles of the feet: you

* The common classification of the senses which makes the touch comprehend the sense of heat and cold, is here adopted; though, certainly, there seems almost as little reason for ranging this under touch, as for ranging sight, smell, hearing, and taste under the same head.

instantly dream of walking over hot mould, or ashes, or a stream of lava, or having your feet burnt by coming too near the fire. But the effect of falling asleep in a stream of cold air, as in an open carriage, varies this experiment in a very interesting, and, indeed, instructive manner. You will, instantly that the wind begins to blow, dream of being upon some exposed point, and anxious for shelter, but unable to reach it; then you are on the deck of a ship, suffering from the gale—you run behind a sail for shelter, and the wind changes, so that it still blows upon you—you are driven to the cabin, but the ladder is removed, or the door locked. Presently you are on shore, in a house with all the windows open, and endeavour to shut them in vain; or, seeing a smith's forge, you are attracted by the fire, and suddenly a hundred bellows play upon it, and extinguish it in an instant, but fill the whole smithy with their blast, till you are as cold as on the road. If you from time to time awake, the moment you fall asleep again, the same course of dreaming succeeds in the greatest variety of changes that can be rung on our thoughts.*

But the rapidity of these changes, and of the succession of ideas, cannot be ascertained by this experiment: it is most satisfactorily proved by another. Let any one who is extremely overpowered with drowsiness—as after sitting up all night, and sleeping none the next day—lie down and begin to dictate: he will find himself falling asleep after uttering a few words, and he will be awakened by the person who writes repeating the last word, to show he has written the whole; not above five or six seconds may elapse, and the sleeper will find it at first quite impossible to believe that he has not been asleep for hours, and will chide the amanuensis for having fallen asleep over his work, so great apparently will be the length of the

* This happened to me many years ago when travelling in Sweden by night. Lord Stuart, who was with me, slept sounder and did not feel it.

dream which he has dreamt, extending through half a lifetime. This experiment is easily tried: again and again the sleeper will find his endless dream renewed; and he will always be able to tell in how short a time he must have performed it. For suppose eight or ten seconds required to write the four or five words dictated, sleep could hardly begin in less than four or five seconds after the effort of pronouncing the sentence; so that, at the utmost, not more than four or five seconds can have been spent in sleep. But, indeed, the greater probability is, that not above a single second can have been so passed: for a writer will easily finish two words in a second; and suppose he has to write four, and half the time is consumed in falling asleep, one second only is the duration of the dream, which yet seems to last for years, so numerous are the images that compose it.*

Another experiment is still more striking, and affords a more remarkable proof both of the velocity of thought, and of the quickness with which its course is moulded to suit any external impression made on the senses. But this experiment is not so easily tried. A puncture made will immediately produce a long dream, which seems to terminate in some such accident as that the sleeper has been wandering through a wood, and received a severe wound from a spear, or the tooth of a wild animal, which at the same instant awakens him. A gun fired in one instance, during the alarm of invasion, made a military man at once dream the enemy had landed, so that he ran to his post, and repairing to the scene of action, was present when the first discharge took place, which also the same moment awakened him.†

Now these facts show the infinite rapidity of thought;

* The experiment related in the text was made by myself after I had been in court all night on a trial, and had not slept next day.

† The ingenious Eastern tale, in the *Spectator*, of the magician who made the prince plunge his head into a pail of water, is founded on facts like those to which I have been referring.

for the puncture and discharge of the gun took place in an instant, and their impression on the senses was as instantaneous; and yet, during that instant, the mind went through a long operation of fancy, suggested by the first part of the impression, and terminated, as the sleep itself was, by the continuation—the last portion of the same impression. Mark what was done in an instant—in a mere point of time. The sensation of the pain or noise beginning is conveyed to the mind, and sets it a thinking of many things connected with such sensations. But that sensation is lost or forgotten for a portion of the short instant during which the impression lasts; for the conclusion of the same impression gives rise to a new set of ideas. The walk in the wood, and the hurrying to the post, are suggested by the sensation beginning. Then follow many things unconnected with that sensation, except that they grew out of it; and, lastly, comes the wound, and the broadside, suggested by the continuance of the sensation, while, all the time, this continuance has been producing an effect on the mind wholly different from the train of ideas the dream consists of, nay, destructive of that train—namely, the effect of rousing it from the state of sleep, and restoring its dominion over the body. Nay, there may be said to be a third operation of the mind going on at the same time with these two—a looking forward to the *dénouement* of the plot,—for the fancy is all along so contriving as to fit that, by terminating in some event, some result consistent with the impression made on the senses, and which has given rise to the whole train of ideas.

There seems every reason to conclude, from these facts, that we only dream during the instant of transition into and out of sleep, and when our sleep is not complete. That instant is quite enough to account for the whole of what appears a night's dream. It is quite certain we remember no more than ought, according to these experiments, to fill an instant of time; and there can be no reason why we should only recollect this one portion if we had dreamt much more. The fact that we never dream so much as when our rest is frequently broken, proves the same proposition almost to demonstration. An uneasy and restless night passed in bed is always a night studded full with dreams. So, too, a night passed on the road in travelling, by such as sleep well in a carriage, is a night of constant dreaming. Every jolt that awakens or half-awakens us seems to be the cause of a dream. If it be said that we always or generally dream when alseep, but only recollect a portion of our dream, then the question arises why we recollect a dream each time we fall asleep, or are awakened, and no more? If we can recall twenty dreams in a night of interrupted sleep, how is it that we can only recall one or two when our sleep is continued? The length of time occupied by the dream we recollect is the only reason that can be given for our forgetting the rest; but this reason fails if, each time we are roused, we remember separate dreams.

Nothing can be conceived better calculated than these facts to demonstrate the extreme agility of the mental powers, their total diversity from any material substances or actions; nothing better adapted to satisfy us that the nature of the mind is consistent with its existence apart from the body.

The changes which the mind undergoes in its activity, its capacity, its mode of operation, are matter of constant observation, indeed of every man's experience. Its essence is the same; its fundamental nature is unalterable; it never loses the distinguishing peculiarities which separate it from matter; never acquires any of the properties of the latter; but it undergoes important changes, both in the progress of time, and by means of exercise and culture. The development of the bodily powers appears to affect it, and so does their decay; but we rather ought to say, that, in ordinary cases, its improvement is contemporaneous with the growth of the body, and its decline generally is contemporaneous with that of the body, after an advanced period of life. For it is an undoubted fact, and almost universally true, that the mind before extreme old age becomes more sound, and is capable of greater things during nearly thirty years of diminished bodily powers; that, in most cases, it suffers no abatement of strength during ten years more of bodily decline; that, in many cases, a few years more of bodily decrepitude produce no effect upon the mind; and that, in some instances, its faculties remain bright to the last, surviving the almost total extinction of the corporeal endowments. It is certain that the strength of the body, its agility, its patience of fatigue, indeed all its qualities, decline from thirty at the latest; and yet the mind is improving rapidly from thirty to fifty; suffers little or no decline before sixty: and therefore is better when the body is enfeebled, at the age of fifty-eight or fifty-nine, than it was in the acme of the corporeal faculties thirty years before. It is equally certain, that while the body is sensibly decaying, between sixty or sixty-three and seventy, the mind suffers hardly any loss of strength in the generality of men; that men continue to seventy-five or seventy-six in the possession of all their mental powers, while few can then boast of more than the remains of physical strength; and instances are not wanting of persons who, between eighty and ninety, or even older, when the body can hardly be said to live, possess every faculty of the mind unimpaired. We are authorized to conclude, from these facts, that unless some unusual and violent accident interferes, such as a serious illness or a grave contusion, the ordinary course of life presents the mind and the body running courses widely different, and in great part of the time in opposite directions; and this affords strong proof, both that the mind is independent of the body, and that its destruction in the period of its entire vigour is contrary *to the analogy* of nature.

The strongest of all the arguments both for the separate existence of mind, and for its surviving the body, remains, and it is drawn from the strictest induction of facts. The body is constantly undergoing change in all its parts. Probably no person at the age of twenty has one single particle in any part of his body which he had at ten; and still less does any portion of the body he was born with continue to exist in or with him. All that he before had has now entered into new combinations, forming parts of other men, or of animals, or of vegetable or mineral substances, exactly as the body he now has will afterwards be resolved into new combinations after his death. Yet the mind continues one and the same, "without change or shadow of turning." None of its parts can be resolved or dispersed; for it is one and single, and it remains unchanged by the changes of the body. The argument would be quite as strong though the change undergone by the body were admitted not to be so complete, and though some small portion of its harder parts* were supposed to continue with us through life.

But observe how strong the inferences arising from these facts are, both to prove that the existence of the mind is entirely independent of the existence of the body, and to show the probability of its surviving! If the mind continues the same while all or nearly all the body is changed, it follows that the existence of the mind depends not in the least degree upon the existence of the body; for it has already survived a total change of, or, in the common use of the words, an entire destruction of that body. But, again, if the strongest argument to show that the mind perishes with the body, nay, the only argument be, as it indubitably is, derived from the phenomena of death, the fact to which we have been referring affords an answer to this. For the argument is, that we know of no

* Except the enamel of the teeth none such appear to exist; and the teeth of course grow long after the mind exists.

instance in which the mind has ever been known to exist after the death of the body. Now here is exactly the instance desiderated, it being manifest that the same process which takes place on the body more suddenly at death is taking place more gradually, but as effectually in the result, during the whole of life, and that death itself does not more completely resolve the body into its elements and form it into new combinations than living fifteen or twenty years does destroy, by like resolution and combination, the self-same body. And yet after those years have elapsed and the former body has been dissipated and formed into new combinations, the mind remains the same as before, exercising the same memory and consciousness, and so preserving the same personal identity as if the body had suffered no change at all. In short, it is not more correct to say that all of us who are now living have bodies formed of what were once the bodies of those who went before us, than it is to say that some of us who are now living at the age of fifty have bodies which in part belonged to others now living at that and other ages. The phenomena are precisely the same, and the operations are performed in like manner, though with different degrees of expedition. Now all would believe in the separate existence of the soul if they had experience of its existing apart from the body. But the facts referred to prove that it does exist apart from one body with which it once was united, and though it is in union with another, yet as it is not adherent to the same, it is shown to have an existence separate from, and independent of, that body. So all would believe in the soul surviving the body, if after the body's death its existence were made manifest. But the facts referred to prove that after the body's death, that is, after the chronic dissolution which the body undergoes during life, the mind continues to exist as before. Here, then, we have that proof so *much desiderated*—the existence of the soul after the dissolution of the bodily frame with which it was connected. The two cases cannot, in any soundness of reasoning, be distinguished; and this argument, therefore, one of pure induction, derived partly from physical science, through the evidence of our senses, partly from psychological science by the testimony of our consciousness, appears to prove the possible Immortality of the Soul almost as rigorously as "if one were to rise from the dead."

Now we have gone through the first division of this second branch of the subject, and have considered the proofs of the separate and future existence of the soul afforded by the nature of mind. It is quite clear that all of them are derived from a strict induction of facts, and that the doctrines rest upon precisely the same kind of evidence with that upon which the doctrines respecting the constitution and habits of the mind are founded. In truth, the subjects are not to be distinguished as regards the species of demonstration applicable to them—the process by which the investigation of them is to be conducted. That mind has an existence perceivable and demonstrable as well as matter, and that it is wholly different from matter in its qualities, is a truth proved by induction of facts. That mind can exist independent of matter and survive the dissolution of the body, is a truth proved exactly in the same manner, by induction of facts. The phenomena of dreams which lead to important conclusions touching the nature of the mind, lead, and by the selfsame kind of reasoning, to important conclusions of a similar description, touching the mind's existence independent of the body. The facts, partly physical, partly psychological, which show the mind to be unaffected by the decay and by even the total though gradual change of the body during life, likewise show that it can exist after the more sudden change of a similar kind, which we term the dissolution of the body by death. There is no means of separating the two classes of truths, those of Psychology and those of Natural Theology; they are parts of one and the same science; they are ascertained by one and the same process of investigation; they repose upon one and the same kind of evidence; nor can any person, without giving way to a most groundless and unphilosophical prejudice, profess his belief in the former doctrines, and reject the latter. The only difference between the two is that the Theological propositions are of much greater importance to human happiness than Metaphysical.

II. MORAL ARGUMENT, OR EVIDENCE OF THE DEITY'S DESIGNS DRAWN FROM HIS ATTRIBUTES IN CONNEXION WITH THE CONDITION OF THE SPECIES.

The probable designs of Divine Providence with respect to the future lot of man are to be gathered in part from the nature of the mind itself, the work of the Deity, and in part from the attributes of the Deity, ascertained by an examination of his whole works. It thus happens that a portion of this head of the argument has been anticipated in treating the other head, the nature of the mind. Whatever qualities of the soul show it to differ from matter, both make it improbable that it should perish with the body, and make it improbable that the Deity should destine it to such a catastrophe; and whatever facts show that it can survive a total change of the body during life, show likewise the probability that the same being who endowed it with that capacity will suffer it, in like manner, to continue in being after the more sudden change which the body undergoes at death.

The argument built upon the supposed designs of the Creator requires to be handled in a humble and submissive spirit; but, if so undertaken, there is nothing in it which can be charged with presumption, or deemed inconsistent with perfect though rational devotion. In truth, all the investigations of Natural Theology are equally liable to such a charge; for to trace the evidences of design in the works of nature, and inquire how far benevolence presides over their formation and maintenance—in other words, to deduce from what we see, the existence of the Deity, and speculate upon His wisdom and goodness in the creation and government of the universe—is just as daring a thing, and exactly of the same kind of audacity, as to speculate upon His probable intentions with respect to the future destiny of man.

The contemplation of the Deity's goodness, as deducible from the great preponderance of instances in which benevolent design is exhibited, when accompanied with a consideration of the feelings and wishes of the human mind, gives rise to the first argument which is usually adduced in favour of the Immortality of the Soul. There is nothing more universal or more constant than the strong desire of immortality which possesses the mind, and compared with which its other wishes and solicitudes are but faint and occasional. That a benevolent being should have implanted this propensity without the intention of gratifying it, and to serve no very apparent purpose unless it be the proving that it is without an object, appears difficult to believe: for certainly the instinctive fear of death would have served all the purposes of self-preservation without any desire of immortality being connected with it, although there can be no doubt that this desire, or at least the anxiety about our future destiny, is intimately related to our dread of dissolution. But the inference acquires additional strength from the consideration that the faculties of the mind ripen and improve almost to the time of the body's extinction, and that the destruction of the soul at the moment of its being fitter than ever for worthy things seems quite inconceivable.

The tender affections so strongly and so universally operating in our nature afford another argument of a like kind. No doubt the purpose to which they are subservient in this life is much more distinctly perceivable; yet still it is inconsistent with the provisions of a benevolent Power to suppose that we should be made susceptible of such vehement feelings, and be suffered to indulge in them, so as to make our happiness chiefly consist in their gratification, and that then we should suddenly be made to undergo the bitter pangs of separation, while, by our surviving, those pangs are lengthened out without any useful effect resulting from our sufferings. That such separations should be eternal appears irreconcilable with the strength of the affections wounded, and with the goodness so generally perceived in the order of the universe. The supposition of a re-union hereafter overcomes the difficulty, and reconciles the apparent inconsistency.

The unequal distribution of rewards and punishments in this world, that is, the misery in which virtue often exists, and the prosperity not seldom attendant upon vice, can in no way be so well accounted for, consistently with the scheme of a benevolent Providence, as by the supposition of a Future State.

But perhaps there is nothing more strongly indicative of such a design in the Creator than the universal prevalence of religion amongst men. There can hardly be found a tribe so dark and barbarous as to be without some kind of worship, and some belief in a future state of existence. Now all religions are so far of God that he permits them; he made and preserves the faculties which have invented the false ones, as well as those which comprehend and treasure up the true faith. Religious belief, religious observance, the looking forward to a future existence, and pointing to a condition in which the deeds done on earth shall be visited with just recompense, are all facts of universal occurrence in the history and intellectual habits of the species. Are they all a mere fiction? Do they indeed signify nothing? Is that a mere groundless fancy, which in all places, in all ages, occupies and has occupied the thoughts and mingled itself with the actions of all mankind, whether barbarous or refined?*

But if it be said that the belief of such a state is subservient to an important use, the restraining the passions and elevating the feelings, it is obvious to reply, that so great a mechanism to produce this effect very imperfectly and precariously, appears little consistent with the ordinary efficacy and simplicity of the works of Providence, and that the disposition to shun vice and debasement could have been more easily and more certainly implanted by making them disgusting. True, there would then have been little merit in the restraint; but of what value is the production of such merit, if the mind which attains it and becomes adorned by it has no sooner approached perfection than it ceases to exist at all? The supposition of a Future State at once reconciles all inconsistencies here as before, and enables us to comprehend why virtue is taught by the hopes of another life, as well as why those hopes, and the grounds they rest on, form so large a portion of human contemplation.

That the existence of the soul in a new state after the entire dissolution of the body—nay, that the existence of the body itself in a new state, after passing through death, is nothing contrary to the analogies which nature presents, has been oftentimes observed, and is a topic much dwelt upon, especially by the ancient philosophers. The extraordinary transformations which insects undergo have struck men's imaginations so powerfully in contemplating this subject, that the soul itself was deemed of old to be aptly designated under the emblematical form of a butterfly, which having emerged from the chrysalis state, flutters in the air, instead of continuing to crawl on the earth, as it did before the worm it once was ceased to exist. The instance of the fœtus of animals, and especially of the human embryo, has occupied the attention of

* *Notes* VIII. and IX.

modern inquirers into this interesting subject. Marking the entire difference in one state of existence before and after birth, and the diversity of every one animal function at those two periods, philosophers have inferred, that as on passing from the one to the other state of existence so mighty a change is wrought, without any destruction either of soul or body, a like transition may take place at death, and the event which appears to close our being may only open the portals of a new, and higher, and more lasting condition. As far as such considerations suggest analogies, they furnish matter of pleasing contemplation, perhaps lend even some illustration to the argument. Nevertheless they must be regarded as exceedingly feeble helps in this latter respect, if indeed their aid be not of a doubtful, and even dangerous kind. They are all drawn from material objects,—all rest upon the properties and the fortunes of corporeal existences. Now the stronghold of those who maintain the Immortality of the Soul, and, indeed, all the doctrines of Natural Theology, is the entire difference between mind and matter, and the proofs we have constantly around us, and within us, of existences as real as the bodies which affect our outward senses, but resembling those perishable things in no one quality, no one habit of action, no one mode of being.

Upon the particulars of a future state—the kind of existence reserved for the soul—the species of its occupations and enjoyments—Natural Theology is, of course, profoundly silent; but not more silent than Revelation. We are left wholly to conjecture, and in a field on which our hopelessness of attaining any certain result is quite equal to our interest in the success of the search. Indeed, all our ideas of happiness in this world are such as rather to disqualify us for the investigation, or what may more fitly be termed the imagination. Those ideas are, for the most part, either directly connected with the senses, or derived from our condition of weakness here, which occasions the formation of connexions for mutual comfort and support, and gives to the feebler party the feeling of allegiance, to the stronger the pleasure of protection. Yet may we conceive that, hereafter, such of our affections as have been the most cherished in life shall survive and form again the delight of meeting those from whom death has severed us—that the soul may enjoy the purest delights in the exercise of its powers, above all, for the investigation of truth—that it may expatiate in the full discovery of whatever has hitherto been most sparingly revealed, or most carefully hidden from its view—that it may be gratified with the sight of the useful harvest reaped by the world from the good seed which it helped to sow. We can only conjecture or fancy. But these, and such as these, are pleasures in which the gross indulgences of sense have no part, and which are even removed above the less refined of our moral gratifications: they may, therefore, be supposed consistent with a pure and faultless state of spiritual being.

Perhaps the greatest of all the difficulties which we feel in forming such conjectures, regards the endless duration of an immortal existence. All our ideas in this world are so adapted to a limited continuance of life—not only so moulded upon the scheme of a being incapable of lasting beyond a few years, but so inseparably connected with a constant change even here—a perpetual termination of one stage of existence and beginning of another—that we cannot easily, if at all, fancy an eternal, or even a long-continued, endurance of the same faculties, the same pursuits, and the same enjoyments. All here is in perpetual movement—ceaseless change. There is nothing in us or about us that abides an hour—nay, an instant. Resting-place there is none for the foot—no haven is provided where the mind may be still. How then shall a creature, thus wholly ignorant of repose—unacquainted with any continuation at all in any portion of his existence—so far abstract his thoughts from his whole experience as to conceive a long, much more a perpetual, duration of the same powers, pursuits, feelings, pleasures? Here it is that we are the most lost in our endeavours to reach the seats of the blessed with our imperfect organs of perception, and our inveterate and only habits of thinking.*

It remains to observe, that all the speculations upon which we have touched under this second subdivision of the subject, the moral argument, are similar to the doctrines of inductive science—at least to such of those doctrines as are less perfectly ascertained; but the investigation is conducted upon the same principles. The most satisfactory proofs of the soul's immortality are those of the first, or psychological class, derived from studying the nature of mind; those of the second class which we have last been surveying, derived from the condition of man in connexion with the attributes of the Deity, are less distinct and cogent; nor would they be sufficient of themselves; but they add important confirmation to the others; and both are as truly parts of legitimate inductive science as any branch—we may rather say, any *other* branch of moral philosophy.

* The part of Dean Swift's satire which relates to the *Stulbrugs* may possibly occur to some readers as bearing upon this topic. That the staunch admirers of that singularly-gifted person should have been flung into ecstacies on the perusal of this extraordinary part of his writings, needs not surprise us. Their raptures were full easily excited; but I am quite clear they have given a wrong gloss to it, and heaped upon its merits a very undeserved praise. They think that the picture of the Stulbrugs was intended to wean us from a love of life, and that it has well accomplished its purpose. I am very certain that the Dean never had any such thing in view, because his sagacity was far too great not to perceive that he only could make out this position by a most undisguised begging of the question. How could any man of the most ordinary reflection expect to wean his fellow-creatures from love of life by describing a sort of persons who at a given age lost their faculties, and became doting drivelling idiots? Did any man breathing ever pretend that he wished to live, not only for centuries but even for threescore years and ten, bereaved of his understanding, and treated by the law and by his fellow-men as in hopeless incurable dotage? The passage in question is much more likely to have proceeded from Swift's exaggerated misanthropy, and to have been designed as an antidote to human pride, by showing that our duration is *necessarily limited*—if, indeed, it is not rather to be regarded as the work *of mere whim and caprice.*

SECTION VI.

LORD BACON'S DOCTRINE OF FINAL CAUSES.*

It now appears, that when we said that Natural Theology can no more be distinguished from the physical, psychological, and ethical sciences, in respect of the evidence it rests upon and the manner in which its investigations are to be conducted, than the different departments of those sciences can be distinguished from each other in the like respect, we were only making an assertion borne out by a close and rigorous examination of the subject. How, then, comes it to pass, it may be asked, that the father of Inductive Philosophy has banished the speculation of Final Causes from his system, as if it were no branch of inductive science? A more attentive consideration of the question will show, *first*, that the sentence which he pronounced has been not a little misunderstood by persons who looked only at particular aphorisms, without duly regarding the context and the occasion; and, *secondly*, that Lord Bacon may very probably have conceived a prejudice against the subject altogether, from the abuses, or indeed perversions, to which a misplaced affection for it had given rise in some of the ancient schools of philosophy.

That Lord Bacon speaks disparagingly of the inquiry concerning Final Causes, both when he handles it didactically, and when he mentions it incidentally, is admitted. He enumerates it among the errors that spring from the restlessness of mind (*impotentia mentis*), which forms the fourth class of the idols of

* Note X.

the species (*idola tribus*) or causes of false philosophy, connected with the peculiarities of the human constitution.* In other parts of the same work he descants upon the mischiefs which have arisen in the schools from mixing the doctrines of natural religion with those of natural philosophy;† and he more than once treats of the inquiry concerning Final Causes as a barren speculation, comparing it to a nun or a vestal consecrated to heaven.‡ But a nearer examination of this great authority will show that it is not adverse to our doctrine.

1. First of all it is to be remarked, that Lord Bacon does not disapprove of the speculation concerning Final Causes absolutely, and does not undervalue the doctrines of Natural Religion, so long as that speculation and those doctrines are kept in their proper place. His whole writings bear testimony to the truth of this proposition. In the *Parasceve* to natural and experimental history, which closes the *Novum Organum*, he calls the history of the phenomena of nature a volume of the work of God, and as it were another Bible — "volumen operum Dei, et tanquam altera scriptura."§ In the first book of the *De Dignitate*, he says there are two books of religion to be consulted—the Scriptures, to tell the will of God, and the book of creation, to show his power.‖ Accordingly he maintains elsewhere ¶ that a miracle was never yet performed to convert atheists, because these might always arrive at the knowledge of a Deity by the light of nature. Nor ought we to pass over the remarkable passage of the *Cogitata et Visa*, in which he propounds the use of Natural Philosophy as the

* Nov. Org. lib. i. Aph. 48.

† Ib. Aph. 96; and De Dig. et Aug. lib. i.

‡ "Sterilis et tanquam virgo Deo sacra non parit."—["A virgin barren and, as it were, consecrated to God, never brings forth."]—c. 5. *De Dig.* lib. iii.

§ "The volume of the works of God, and, as it were, another Scripture." —*Parasceve*, c. 9. ‖ Lib. i. ¶ Ib. lib. iii. c. 13.

cure for superstition and the support of true religion. "Naturalem Philosophiam, post verbum Dei, certissimam superstitionis medicinam, eandem probatissimum fidei alimentum esse. Itaque merito religioni tanquam fidatissimam et acceptissimam ancillam attribui, cum altera voluntatem Dei, altera potestatem manifestet."* If the earlier part of the passage left any doubt of the kind of service which religion was to derive from inductive science, the last words clearly show that it could only be by the doctrine of final causes.

2. But further, he distinctly classes natural religion among the branches of legitimate science; and it is of great and decisive importance to our present inquiry that we should mark the particular place which he assigns to it. He first divides science into two great branches, Theology and Philosophy—comprehending under the former description only the doctrines of revelation, and under the latter all human science. Now, after expressly excluding Natural Religion † from the first class, he treats it as a part of the second. The second, or philosophy, is divided into three parts, according as its object is the Deity, Nature, or Man. The first of these subdivisions constitutes Natural Religion, which he says may be termed Divine knowledge, if you regard its object, but Natural knowledge, if you consider its nature and evidence ("ratione informationis scientia naturalis censeri potest."‡) That he places it in a different subdivision from Natural Philosophy proves nothing; for he classes anatomy, medicine, and intellectual philosophy also in a different subdivision: they come under the head of Human Philosophy, or the science of man, as contradistinguished from Natural Theology and Natural Philosophy, or the science of God and of external objects. Many objections may undoubtedly

* Francisci Baconi, Cogitata et Visa. † De Dig. lib. iii. c. 1.

‡ "In respect of its information or science it may be reckoned natural philosophy."—*De Dig.* lib. iii. c. 2.

be made to this classification, of which it is perhaps enough to say, that it leads to separating optics as well as anatomy and medicine* from natural philosophy. But, at all events, it shows both that Lord Bacon deemed Natural Theology a fit object of philosophical inquiry, and that he regarded the inductive method as furnishing the means by which the inquiry was to be conducted.

3. The general censure upon the doctrine of Final Causes to which we have in the outset adverted, as conveyed by certain incidental remarks, is manifestly directed against the abuse of such speculations, and more especially in the ancient schools of antiquity. Lord Bacon justly objects to the confounding of final with efficient or physical causes; he marks the loose and figurative language to which this confusion has given rise; he asks if it is philosophical to describe the eye as Aristotle, Galen, and others do, with the eyelids and eyelashes as a wall and a hedge to protect it; or the bones as so many beams and pillars to support the body;† and he is naturally apprehensive of the danger which may result from men introducing fancies of their own into science, and, above all, from their setting out with such fancies, and then making the facts bend to humour them. This is, indeed the great abuse of the doctrine of final causes; and the more to be dreaded in its consequences, because of the religious feelings which are apt to mix themselves with such speculations, and to consecrate error.‡

* *De Dig.* lib. iv. c. 3. He treats of the desiderata in optics under the head of the human mind—the senses.

† Ib. lib. iii. c. 4.

‡ This idea is expressed by Bacon, with his wonted felicity, in the 75th Aphorism. "Pessima enim res est errorum apotheosis; et pro peste intellectûs habenda est, si vanis accedat veneratio."—["The worst of all this is the consecration of errors, and it is to be accounted the pest of the understanding if vain things become objects of veneration."]—*Nov. Org.* lib. i. He gives an instance of this folly in the perverted use made of some portions of the Bible history—"Huic vanitati nonnulli ex modernis summâ levitate ita indulserunt, ut in primo capitulo Geneseôs et in libro Job et

4. The objections of Lord Bacon are the more clearly shown to be levelled against the abuse only, that we find him speaking in nearly similar terms of logic and the mathematics as having impeded the progress of natural science. In the passage already referred to, and which occurs twice in his books, where the Platonists are accused of mixing Natural Religion with philosophy, the latter Platonists (or Eclectics) are in the same words charged with corrupting it by the mathematics, and the Peripatetics by logic.* Not certainly that the greatest logician of modern times could undervalue either his own art or the skill of the analyst, but because Aristotle through dialectic, and Proclus through geometrical pedantry, neglected that humbler but more useful province of watching and interpreting nature, and used the instruments furnished by logic and the mathematics, not to assist them in classifying facts or in reasoning from them, but to construct phantastic theories, to which they made the facts bend.

When rightly examined, then, the authority of Lord Bacon appears not to oppose the doctrine which we are seeking to illustrate. Yet it is possible that a strong impression of the evils occasioned by the abuse of these speculations may have given him a less favourable opinion of them than they deserved. It appears that he had even conceived some prejudice against logic and the mathematics from a similar cause; and he manifests it, not only in the passages already referred to, but in that portion of his treatise *De Dig. et Aug.* in which he treats of mathematical as an appendix to physical science, expressing much hesitation whether to rank it as a science, and delivering himself with some asperity

aliis scripturis sacris, Philosophiam Naturalem fundare conati sint; *inter viva quærentes mortua.*"—[" In this vanity some of the moderns have so far indulged with the utmost thoughtlessness, that they have attempted to found natural philosophy on the first chapter of Genesis and the Book of Job and other Scriptures—*seeking the living among the dead.*"]

* Nov. Org. lib. i. Aph. 96; De Dig. lib. i.

against both logicians and mathematicians.* High as is the authority of this great man—and upon the subject of the present inquiry the highest of all—yet, if it clearly appears that the argument from Final Causes comes within the scope of inductive science, we are bound to admit it within the circle of legitimate human knowledge, even if we found the father of that science had otherwise judged. It is clear that, had he now lived, he would himself have rejected some speculations as wholly beyond the reach of the human faculties, which he unhesitatingly ranges among the objects of sound philosophy.† It is equally undeniable that he would have treated others with greater respect than he has shown them.‡ Above all, it is certain that he would never have suffered that the veneration due to his own name should enshrine an idol § to obstruct the progress of truth, and alienate her votaries from the true worship which he himself had founded.

That Lord Bacon has not himself indulged in any speculations akin to those of Natural Theology is, beyond all dispute, true. There is hardly any writer

* "Delicias et festum mathematicorum, qui hanc scientiam physicæ fieri imperare cupiunt. Nescio enim quo fato fiat ut mathematica et logica, quæ ancillarum loca erga physicam se gerere debebant, nihilominus, certitudinem præ se jactantes, dominationem exercere petunt."—["The delight and feast of the mathematicians, who would make this science control natural philosophy; for I know not by what fatality it happens that mathematics and logic, which ought to have behaved as the handmaidens of physics, yet, vaunting their certainty, seek to exercise dominion."]—*De Dig.* lib. iii. c. 6.

† He distinctly considers the "doctrine of angels and spirits" as an "appendix to Natural Theology," and holds that their nature may be investigated by science, including that of unclean spirits or dæmons, which he says hold in this inquiry the same place as poisons do in physics, or vices in ethics.—*De Dig.* lib. iii. c. 2. Natural magic, the doctrine of fascination, the discovery of futurity from dreams and ecstacies, especially in bad health from death-bed glimpses—in a word, divination—he holds to be branches of science deserving of cultivation; though he warns against sorcery, or the practice of witchcraft.—Ib. lib. iv. c. 3, and lib. ii. c. 2.

‡ He complains of treatises of Natural History being "swelled with figures of animals and plants, and other superfluous matter, instead of being enriched with solid observations."—*De Dig.* lib. 2. c. 3.

§ *Idolum* theatri.

upon moral or natural science, in whose works fewer references can be found to the power or wisdom of a superintending Providence. It would be difficult to find in any other author, ancient or modern, as much of very miscellaneous matter upon almost all physical subjects as he has brought together in the *Sylva Sylvarum*, without one allusion to Final Causes. But it must also be admitted, that it would not be easy to find in any other writer of the least name upon physical subjects so little of value, and so much that is wholly unworthy of respect. That work is, indeed, a striking instance of the inequalities of the human faculties. Among the one thousand observations of which it consists, hardly one—of the two hundred and eighteen pages certainly not one—can be found in which there is not some instance of credulity, superstition, groundless hypothesis, manifest error of some kind or other; and nothing at any time given to the world ever exhibited a more entire disregard of all his own rules of philosophizing: for a superficial examination of facts, a hasty induction, and a proneness to fanciful theory, form the distinguishing characters of the whole book. Assuredly it is a proof that the doctrine of Final Causes is not the only parent of a "phantastic philosophy," though the other base undergrowth of "heretical religion"* may not be found in the recesses of the Sylva.

Descartes, whose original genius for the abstract sciences fixed an æra in the history of pure mathe-

* This striking and epigrammatic antithesis occurs more than once in his writings. Thus, in the *Nov. Org.* lib. i. Aph. 65—"Ex divinorum et humanorum malesana admixtione, non solum educitur philosophia phantastica, sed etiam religio hæretica;"—["From the unwholesome admixture of divine and human things there comes not only a fantastic philosophy, but an heretical religion."]—and again, in *De Dig. et Aug.* lib. iii. c. 2, speaking of the abuse of speculations touching natural religion, he remarks on the "incommoda et pericula quæ ex eo (abusû) tum religioni, tum philosophiæ impendent, utpote qui religionem hæreticam procudit et philosophiam phantasticam et superstitiosam."—["The inconveniences and dangers which, from that abuse, threaten both religion and philosophy, coining an heretical religion and a fantastical and superstitious philosophy."]

matics, as remarkable as Bacon's genius did in that of logic, like him failed egregiously as a cultivator of natural philosophy; and he excluded Final Causes altogether from his system as a preposterous speculation—an irreverent attempt to penetrate mysteries hidden from human eyes by the imperfection of our nature. But it is to be observed, that all the successful cultivators of physical science have, as if under the influence of an irresistible impulsion, indulged in the sublime contemplations of Natural Religion. Nor have they fallen into this track from feeling and sentiment; they have pursued it as one of the paths which inductive philosophy opens to the student of nature. To say nothing of Mr. Boyle, one of the earliest cultivators of experimental philosophy, whose works are throughout imbued with this spirit, and who has left a treatise expressly on the subject of Final Causes, let us listen to the words of Sir Isaac Newton himself. The greatest work of man, the Principia, closes with a swift transition from its most difficult investigation, the determination and correction of a comet's trajectory upon the parabolic hypothesis,* to that celebrated scholium, upon which Dr. Clarke's argument *à priori* for the existence of a Deity is built. But whatever may be deemed the soundness of that argument, or the intrinsic value of the eloquent and sublime passages which lay its foundation, its illustrious author at the same time points our attention to the demonstration from induction, and in the most distinct and positive terms sanctions the doctrine, that this is a legitimate branch of natural knowledge. "Hunc (Deum) cognoscimus per proprietates ejus et attributa et per sapientissimas et optimas rerum structuras et causas finales, et admiramur ob prospectiones."—"Deus sine dominio, providentiâ, et causis finalibus, nihil aliud est quam fatum et natura." —"Et hæc de Deo—de quo utique ex phænomenis

* Principia, lib. iii. Prop. xli. and xlii.

disserere ad philosophiam naturalem pertinet." *—(*Scholium Generale.*)

And if he could not rest from his immortal labours in setting forth the system of the Universe, without raising his mind to the contemplation of Him who "weighed the mountains in scales and the hills in a balance," so neither could he pursue the more minute operations of the most subtile material agent, without again rising towards Him who said "Let there be light." The most exquisite investigation ever conducted by man of the laws of nature by the means of experiment, abounds in its latter portion with explicit references to the doctrines of Natural Theology, and with admissions that the business of physical science is "to deduce causes from effects till we come to the very First Cause," and that "every true step made in inductive philosophy is to be highly valued, because it brings us nearer to the First Cause."†

* "Him (God) we know by his qualities and attributes, and by his most wise and excellent structure, and by final causes; and we admire him on account of our foresight of the future."—"A God without dominion, providence, and final causes is nothing but fate and nature."—"And thus far of God, to inquire concerning whom from the phenomena no doubt it belongs to natural philosophy."

† *Optics*, Book iii. Query 28.—"How came the bodies of animals to be contrived with so much art, and for what ends were the several parts? Was the eye contrived without skill in optics, and the ear without knowledge of sound?" (See, too, Query 31.)

SECTION VII.

OF SCIENTIFIC ARRANGEMENT, AND THE METHODS OF ANALYSIS AND SYNTHESIS.

HAVING shown that Natural Theology is a branch of inductive science—partly physical, partly intellectual and moral—it is of comparatively little importance to inquire whether or not it can be kept apart from the other branches of those sciences. In one view of this question we may say, that there is no more ground for the separation than there would be for making a distinct science of all the propositions in Natural Philosophy which immediately relate to the human body—whereby we should have portions of dynamics, pneumatics, optics, chemistry, electricity, and all human anatomy and pathology as contradistinguished from comparative, reduced under one and the same head—a classification, indeed, resembling Lord Bacon's. But in another, and, as it seems, the more just view, there is a sufficient number of resemblances and differences, and the importance of the subject is sufficient, to justify the making a separate head of Natural Theology. The question is entirely one of convenience; nothing of essential moment turns upon the classification; and there is obviously an advantage in having the truths collected in one body, though they are culled from the various parts of Physical and Metaphysical science to which they naturally belong. All that is needful is, constantly to keep in mind the identity of the evidence on which these truths rest with that which is the groundwork of those other parts of philosophy.

Although, however, convenience and the paramount importance of the subject seem to require such a separation, it is manifest that much of theology must still be found intermingled with physics and psychology, and there only; for the truths of Natural Theology being sufficiently demonstrated by a certain induction of facts—a certain number of experiments and observations—no further proof is required; and to assemble all the evidence, if it were possible, would be only encumbering the subject with superfluous proofs, while the collection would still remain incomplete, as every day is adding to the instances discovered of design appearing in the phenomena of the natural and moral world. It has been said, indeed, that a single well-established proof of design is enough, and that no additional strength is gained to the argument by multiplying the instances. We shall afterwards show with what limitations this proposition is to be received; but for our present purpose it is sufficient, that, at all events, a certain definite number of instances are of force enough to work out the demonstration; and yet in every branch of physics and psychology new instances are presented at each step we make. These instances are of great importance; they are to be carefully noted and treasured up; they form most valuable parts of those scientific inquiries, conveying, in its purest form and in its highest degree, the gratification of contemplating abstract truths, in which consists the whole ef the pleasure derived from science, properly so called—that is, from science as such, and as independent of its application to uses or enjoyments of a corporeal kind.

An apprehension has frequently been entertained by learned and pious men—men of a truly philosophical spirit—lest the natural desire of tracing design in the works of nature should carry inquirers too far, and lead them to give scope to their imagination rather than contain their speculations within the bounds of strict reasoning. They have dreaded the introduction of what Lord Bacon calls a "phantastic philosophy;"

and have also felt alarm at the injuries which religion may receive from being exposed to ridicule, in the event of the speculations proving groundless upon a closer examination. But it does not appear reasonable that philosophers should be deterred by such considerations from anxiously investigating the subject of Final Causes, and giving it the place which belongs to it in all their inquiries; provided that they do not suffer fancy to intermix with and disturb their speculations. If they do, they commit the greatest error of which reasoners can be guilty—an error against which it is the very object of inductive philosophy to guard; but it is no more an error in this, than in the other investigations of science. He who imagines design where there is none; he who either assumes facts in order to build upon them an inference favourable to Natural Religion, or from admitted facts draws such an inference fancifully, and not logically, comes within the description of a false philosopher; he prefers the hypothetical to the inductive method; he cannot say with his master, "*hypotheses non fingo;*"* he renounces the modern, and recurs to the exploded modes of philosophizing. But he is not the more a false philosopher, and does not the more sin against the light of improved science, for committing the offence in the pursuit of theological truth. He would have been liable to the same charge if he had resorted to his fancy instead of observation and experiment while in search of any other scientific truth, or had hypothetically assumed a principle of classifying admitted phenomena, instead of rigorously deducing it from examining their circumstances of resemblance and of diversity.

That any serious discredit can be brought upon the science of Natural Theology itself, from the failures to which such hypothetical reasonings may lead, seems not very easy to conceive. Vain and superficial minds

* Principia, lib. iii. Sch. Gen.

may take any subject for their ridicule, and may laugh, as they heretofore have laughed, at the mechanician and the chemist as well as the theologian, when they chance to go astray in their searches after truth. Yet no one ever thought of being discouraged from experimental inquiries, because even the strictest prosecution of the inductive method cannot always guard against error; nor did the Scriblerus of the combined wits ever deter one student of Nature. It is of the essence of all investigations of merely contingent truth, that they are exposed to casualties which do not beset the paths of the geometrician and the analyst. A conclusion from one induction of facts may be well warranted until a larger induction obliges us to abandon it, and adopt another. Yet no one deems chemistry discredited because a body considered in one state of our knowledge to be a compound acid has since appeared rather to be a simple substance, bearing to the acids no resemblance in its composition; nor would the optical discoveries of Sir Isaac Newton be discredited, much less the science he cultivated be degraded, if the undulatory hypothesis should, as appears likely enough on a fuller inquiry, become established by strict proof. Yet such errors, or rather such imperfect and partial views, were the result of a strict obedience to the inductive rules of philosophizing. How much less ground for cavil against either those rules, or the sciences to which they are applicable, would be afforded by the observations of those who had mistaken their way through a neglect of inductive principle, and by following blindly false guides!

While then, on the one hand, we allow Natural Theology to form a distinct head or branch, the other sciences must of necessity continue to class its truths among their own; and thus every science may be stated to consist of *three* divisions:—1. The truths which it teaches relative to the constitution and action of matter or of mind;—2. The truths which it teaches relative to theology; and 3. The application of both classes of truths to practical uses, physical or moral. Thus, the science of pneumatics teaches, under the *first* head, the doctrine of the pressure of the atmosphere, and its connexion with respiration, and with the suspension of weights by the formation of a vacuum. Under the *second* head, it shows the adaptation of the lungs of certain animals to breathe the air, and the feet of others to support their bodies, in consequence of both being framed in accordance with the former doctrine—that is, with the law of pressure—and thus demonstrates a wise and beneficent design. Under the *third* head, it teaches the construction of barometers, steam engines, &c., while the contemplation of the Divine wisdom and goodness inculcates piety, patience, and hope.

But, it may be said, that in this classification of the objects of science, we omit one ordinarily reckoned essential—the explanation of phenomena. The answer is, that such a classification is not strictly accurate, as no definite line can be drawn between the explanation of phenomena and the analytical process by which the truths themselves are established; in a word, between analysis and synthesis in the sciences of contingent truth. For the same phenomena which form the materials of the analytical investigation—the steps that lead us to the proposition or discovery—would, in a reversed order, become the subjects of the synthetical operation: that is, the things to be explained by means of the proposition or discovery, if we had been led to it by another route, in other words, if we had reached it by means of other phenomena of the like kind, referrible to the same class, and falling within the same principle or rule. Thus the experiments upon the prismatic spectrum prove the sun's light to be composed of rays of different refrangibility. This being demonstrated, we may explain by means of it the *phenomena which* form the proofs of the first proposition of the "*Optics*," that lights which differ in colour differ in refrangibility—as that a parallelogram of two colours refracted through a prism has its sides no longer parallel; or, having shown the different refrangibility by the prismatic phenomena, we may explain why a lens has the focus of violet rays nearer than the focus of red, while this experiment is of itself one of the most cogent proofs of the different refrangibility. It is plain that, in these cases, the same phenomena may be made indiscriminately the subject matter either of analysis or synthesis. So, one of the proofs given of latent heat is, that after you heat a bar of iron once or twice by hammering it, the power of being thus heated is exhausted, until by exposing it to the fire that power is restored. Yet, suppose we had proved the doctrine of the absorption of heat by other experiments—as by the effects on the thermometer of liquids of different temperatures mixed together—the phenomenon of the iron bar would be explicable by that doctrine thus learnt. Again, another proof of the same truth is the production of heat by the sudden condensation of gaseous fluids, and of cold by evaporation, the evolution of heat being inferred from the former, and its absorption from the latter operation. But if the experiments upon the mixture of fluids of different temperatures, and other facts, had sufficiently proved the disappearance of heat in its sensible form, and its being held in a state in which it did not affect the thermometer, we should by means of that doctrine have been able to account for the refrigerating effect of evaporation, and the heating power of condensation.

It cannot, then, be a real and an accurate distinction, or one founded on the nature of the thing, which depends on the accident of the one set of facts having been chosen for the instruments of the analytical, and the other set for the subjects of the synthetical operation, each set being alike applicable to either use.

For, in order that the synthesis may be correct, nay, in order that it may be strict and not hypothetical, it is obviously necessary that the phenomena should be of such a description as might have made them subservient to the analysis. In truth, both the operations are essentially the same—the generalization of particulars—the arranging or classifying facts so as to obtain a more general or comprehensive fact; and the explanation of phenomena is just as much a process of generalization or classification as the investigation of the proposition itself, by means of which you are to give the explanation. We do not perform two operations, but one, in these investigations. We do not in reality first find by the prism that light is differently refrangible, and then explain the rainbow—or show by the air-pump that the atmosphere presses with the weight of so many pounds upon a square foot, and then explain the steam engine and the fly's foot—or prove, by burning the two weighed gases together and burn-iron in one of them, that water is composed of them both, and that rust is the metal combined with one, and then explain why iron rusts in water. But we observe all these several facts, and find that they are related to each other, and resolvable into three classes—that the phenomena of the prism and of the shower are the same, the spectrum and the rainbow being varieties of the same fact, more general than either, and comprehending many others, all reducible within its compass—that the air-pump, the steam engine, the fly's foot, are all the same fact, and come within a description still more general and compendious—that the rusting of iron, the burning of inflammable air, and the partial consumption of the blood in the lungs, are likewise the same fact in different shapes, and resolvable into a fact much more comprehensive.

If, then, the distinction of investigation and explanation, or the analytical and synthetical process, is to be *retained, it can* only be nominal; and it is productive of but little if any convenience. On the contrary, it is calculated to introduce inaccurate habits of philosophizing, and holds out a temptation to hypothetical reasoning. Having obtained a general law, or theory, we are prone to apply it where no induction shows that it is applicable; and perceiving that it would account for the observed phenomena, if certain things existed, we are apt to assume their existence, that we may apply our explanation. Thus we know, that if the walrus's foot, or the fly's, make a vacuum, the pressure of the air will support the animal's weight, and hence we assume that the vacuum is made. Yet it is clear that we have no right whatever to do so; and that the strict rules of induction require us to prove the vacuum before we can arrange this fact in the same class with the other instances of atmospheric pressure. But when we have proved it by observation, it will be said we have gained nothing by our general doctrine. True; but all that the science entitles us to do is, not to draw facts we are half acquainted with under the arbitrary sway of our rule, but to examine each fact in all its parts, and bring it legitimately within the rule by means of its ascertained resemblances—that is, classify it with those others to which we actually find that it bears the common relation. Induction gives us the right to expect that the same result will always happen from the same action operating in like circumstances; but it is of the essence of this inference that the similarity be first shown.

It may be worth while to illustrate this further, as it is an error very generally prevailing, and leads to an exceedingly careless kind of inquiry. The fundamental rule of inductive science is, that no hypothesis shall be admitted—that nothing shall be assumed merely because, if true, it would explain the facts. Thus the magnetic theory of Æpinus is admitted by all to be admirably consistent with itself, and to explain all the phenomena—that is, to tally exactly with the facts observed. But there is no proof at all of the accumulation of electrical or magnetic fluid at the one pole, and other fundamental positions; on the contrary, the facts are rather against them: therefore, the theory is purely gratuitous; and although it would be difficult to find any other, on any subject, more beautiful in itself, or more consistent with all the phenomena, it is universally rejected as a mere hypothesis, of no use or value in scientific research. The inductive method consists in only admitting those things which the facts prove to be true, and excludes the supposing things merely because they square with the facts. Whoever makes such suppositions upon observing a certain number of facts, and then varies those suppositions when new facts come to his knowledge, so as to make the theory tally with the observation—whoever thus goes on touching and retouching his theory each time a new fact is observed which does not fall within the original proposition, is a mere framer of hypotheses, not an inductive inquirer—a fancier, and not a philosopher.

Now, this being the undoubted rule, does not the course of those fall exactly within it, who, having upon a certain class of phenomena, built a conclusion legitimately and by strict induction, employ that conclusion to explain other phenomena, which they have not previously shown to fall within the same description? Take the example of the Torricellian vacuum. Having by that experiment proved the weight of the atmosphere, we have a right to conclude that a tube filled with water forty feet high would have a vacuum in the uppermost seven feet—because we know the relative specific gravities of water and mercury, and might predict from thence that the lighter fluid would stand at the height of thirty-three feet; and this conclusion we have a right to draw, without any experiments to ascertain the existence of a vacuum in the upper part *of the tube*. But we should have no right whatever to draw this conclusion, without ascertaining the specific gravities of the two fluids; for if we did, it would be assuming that the two facts belonged to the same class. So respecting the power of the walrus or the fly to walk up a vertical plane. We know the effects of exhausting the air between any two bodies, and leaving the external atmosphere to press against them: they will cohere. But if from thence we explain the support given to the walrus or the fly without examining their feet, and ascertaining that they do exhaust or press out the air—if, in short, we assume the existence of a vacuum under their feet, merely because were there a vacuum the pressure of the air would produce the cohesion, and thus account for the phenomena—we really only propound a hypothesis. We suppose certain circumstances to exist, in order to classify the fact with other facts actually observed, and the existence of which circumstances is necessary, in order that the phenomena may be reducible under the same head.

There is no reason whatever for asserting that this view of the subject restricts the use of induction by requiring too close and constant a reference to actual observation. The inductive principle is this — that from observing a number of particular facts, we reason to others of the same kind—that from observing a certain thing to happen in certain circumstances, we expect the same thing to happen in the like circumstances. This is to generalize; but then this assumes that we first show the identity of the facts, by proving the similarity of the circumstances. If not, we suppose or fancy, and do not reason or generalize. The tendency of the doctrine that a proposition being demonstrated by one set of facts, may be used to explain another set, has the effect of making us suppose or assume the identity or resemblance which ought to be proved. The true principle is, that induction is the generalizing or classifying of facts by observed resemblances and diversities.

Nothing here stated has any tendency to shackle our experimental inquiries by too rigidly narrowing the proof. Thus, although we are not allowed to suppose any thing merely because, if it existed, other things would be explained; yet, when no other supposition will account for the appearances, the hypothesis is no longer gratuitous; and it constantly happens, that an inference drawn from an imperfect induction, and which would be, on that state of the facts, unauthorized because equivocal and not the only supposition on which the facts could be explained, becomes legitimate on a further induction, whereby we show that, though the facts first observed might be explained by some other supposition, yet those facts newly observed could to no other supposition be reconciled. Thus, the analytical experiment on the constitution of water, by passing steam over red hot iron, is not conclusive, because, although it tallies well with the position that water consists of oxygen and hydrogen, yet it would also tally with another supposition, that those gases were produced in the process, and not merely separated from each other; so that neither oxygen nor hydrogen existed in the water any more than acid and water exist in coal and wood, but only their elements, and that, like the acid and water, the products of the destructive distillation of those vegetable substances, the oxygen and hydrogen were compounded and in fact produced by the process. But when, beside the analytical, we have the synthetical experiments of Mr. Cavendish and Dr. Priestley *—when we find that by

* Dr. Priestley drew no conclusion of the least value from his experiments. But Mr. Watt, after thoroughly weighing them, by careful comparison with other facts, arrived at the opinion that they proved the composition of water. This may justly be said to have been the discovery of that great truth in chemical science. I have examined the evidence, and am convinced that he was the first discoverer, in point of time, although it is very possible that Mr. Cavendish may have arrived at the same truth from his own experiments, without any knowledge of Mr. Watt's earlier process of reasoning.—See *Life of Watt*, and Paper annexed *to M. Arago's Eloge.*

burning the two gases in a close vessel, they disappear, and leave a weight of water equal to their united weights—we have a fact not reconcilable to any other supposition, except that of the composition of this fluid. It is as when, in solving a problem, we fix upon a point in one line, curved or straight, because it answers one of the conditions—it may be the right point, or it may not, for all the other points of the line equally answer that condition; but when we also show that the remaining conditions require the point to be in another line, and that this other intersects the former in the very point we had assumed, then no doubt can exist, and the point is evidently the one required, none other fulfilling all the conditions.

We have used the words *analytical* and *synthetical* as applicable to the experiments of resolution and composition; and in this sense these terms are strictly correct in reference to inductive operations. But the use of the terms *analysis* and *synthesis* as applicable to the processes of induction—the former being the investigation of truths by experiment or observation, and the latter the explaining other facts by means of the truths so ascertained—is by no means so correct, and rests upon an extremely fallacious analogy, if there be indeed any analogy, for identity, or even resemblance, there is none. The terms are borrowed from mathematical science, where they denote the two kinds of investigation employed in solving problems and investigating theorems. When, in order to solve a problem, we suppose a thing done which we know not how to do, we reason upon the assumption that the prescribed conditions have been complied with, and proceed till we find something which we already possess the means of doing. This gives us the construction; and the synthetical demonstration consists in merely retracing the steps of the analysis. And so of a theorem: we assume it to be true, and reasoning on that assumption, we are led to something which we know from other sources to be true, the synthesis being the same operation reversed. The two operations consist here, of manifest necessity, of the very same steps—the one being the steps of the other taken in the reverse order. In physics, to make the operation similar to these, the same facts should be the ground or component parts of both. In analysis, we should ascend not only from particulars to generals, but from the same particulars, and then the synthesis would be a descent through the same steps to the particular phenomena from the general fact. But it is a spurious synthesis, unlike the mathematical, and not warranted by induction, to prove the proposition by one set of facts, and by that proposition to explain—that is, classify—another set, without examining it by itself. If we do examine it by itself, and find that it is such as the proposition applies to, then also is it such as might prove the proposition; and the synthesis is here, as in the case of the mathematical investigation, the analysis reversed. As far as any resemblance or analogy goes, there is even a greater affinity between the inductive analysis and the geometrical synthesis, than between those operations which go by the same name; and I hardly know anything in experimental investigation resembling the mathematical analysis, unless it be when, from observing certain facts, we assume a position, and then infer, that if this be true, some other facts must also exist, which we find (from other proofs) really do exist. This bears a resemblance rather to the analytical investigation than to the composition or synthetical demonstration of theorems in the ancient geometry. It is not the course of reasoning frequently pursued in experimental sciences; but a most beautiful example of it occurs in the second part of Dr. Black's experiments on Magnesia Alba and Quick Lime, the foundation of the modern gaseous chemistry.

Upon the whole, the use of these terms is apt to mislead: and, for the reasons which have been assigned, there seems no solidity in the division of inductive inquiry into the two classes.*

* When this section was written, I had not seen Mr. Stewart's learned remarks upon analysis and synthesis in the second volume of his *Elements*, nor was aware of the observations of Dr. Hook, quoted by him, and which show a remarkable coincidence with one of the observations in the text. Mr. Stewart's speculations do not come upon the same ground with mine: but Dr. Hook having reversed the use of the terms analysis and synthesis in experimental science, affords a strong confirmation of the remark which I have ventured to make upon the inaccuracy of this application of mathematical language.—See *Elem. of Phil. of Human Mind*, vol. ii. p. 354, 4to.

PART THE SECOND.

OF THE ADVANTAGES OF THE STUDY OF NATURAL THEOLOGY.

The uses of studying the science to which our inquiries have been directed now demand some consideration. These consist of the pleasures which attend all scientific pursuits, the pleasures and the improvement peculiar to the study of Natural Theology, and the service rendered by this study to the doctrines of Revelation.

SECTION I.

OF THE PLEASURES OF SCIENCE.

As we have established the position that Natural Theology is a branch of Inductive Science, it follows that its truths are calculated to bestow the same kind of gratification which the investigation and the contemplation of scientific truth generally is fitted to give.

That there is a positive pleasure in such researches and such views, wholly independent of any regard to the advantages derived from their application to the aid of man in his physical necessities, is quite undeniable. The ascertaining by demonstration any of the great truths in the mathematics, or proving by experi*ment* any of the important properties of matter, would give a real and solid pleasure, even were it certain that no practical use could be made of either the one or the other. To know that the square of the hypothenuse is always exactly equal to the sum of the squares of the sides of a right-angled triangle, whatever be its size, and whatever the magnitude of the acute angles, is pleasing; and to be able to trace the steps by which the absolute certainty of this proposition is established is gratifying, even if we were wholly ignorant that the art of guiding a ship through the pathless ocean mainly depends upon it. Accordingly we derive pleasure from rising to the contemplation of the much more general truth, of which the discovery of Pythagoras (the 47th proposition of the First Book of Euclid) is but a particular case, and which is also applicable to all similar triangles, and indeed to circles and ellipses also, described on the right-angled triangle's sides; and yet that general proposition is of no use in navigation, nor indeed in any other practical art. In like manner, the pleasure derived from ascertaining that the pressure of the air and the creation of a vacuum alike cause the rise of the mercury in the barometer, and give the power to flies of walking on the ceiling of a room, is wholly independent of any practical use obtained from the discovery, inasmuch as it is a pleasure superadded to that of contemplating the doctrine proved by the Torricellian experiment, which had conferred all its practical benefits long before the cause of the fly's power was found out. Thus again it is one of the most sublime truths in science, and the contemplation of which, as mere contemplation, affords the greatest pleasure, that the same power which makes a stone fall to the ground keeps the planets in their course, moulds the huge masses of those heavenly bodies into their appointed forms, and reduces to perfect order all the apparent irregularities of the system: so that the handful of sand which for an instant ruffles the surface of the lake, acts by the same law which governs, through myriads of ages, the mighty system composed of myriads of worlds. There is a positive pleasure in generalizing facts and arguments—in perceiving the wonderful production of most unlike results from a few very simple principles—in finding the same powers or agents reappearing in different situations, and producing the most diverse and unexpected effects—in tracing unexpected resemblances and differences—in ascertaining that truths or facts apparently unlike are of the same nature, and observing wherein those apparently similar are various: and this pleasure is quite independent of all considerations relating to practical application; nay, the additional knowledge that those truths are susceptible of a beneficial application gives a further gratification of the like kind to those who are certain never to have the opportunity of sharing the benefits obtained, and who indeed may earnestly desire never to be in the condition of being able to share them. Thus, in addition to the pleasure received from contemplating a truth in animal physiology, we have another gratification from finding that one of its corollaries is the construction of an instrument useful in some painful surgical operation. Yet, assuredly, we have no desire ever to receive advantage from this corollary; and our scientific gratification was wholly without regard to any such view. In truth, generalizing —the discovery of remote analogies—of resemblances among unlike objects—forms one of the most pleasing employments of our faculties in every department of mental exertion, from the most severe investigations of the mathematician to the lightest efforts of the wit. To trace the same equality, or other relation, between figures apparently unlike, is the chief glory of the geometrician; to bring together ideas of the most opposite description, and show them in unexpected, yet when suddenly pointed out, undeniable connexion, is the very definition of wit. Nay, the proposition which we have just enunciated is a striking instance of the same general truth; for we have been surveying the resemblance, or rather the identity, in one important particular of two pursuits, in all other respects the most widely remote from each other—mathematics and wit.

If the mere contemplation of scientific truth is the source of real gratification, there is another pleasure, alike remote from all reference to practical use or benefit, and which is obtained by tracing the investigations and demonstration—the steps that lead analytically to the discovery, and synthetically to the proof of those truths. This is a source of pleasure, both by giving us the assurance that the propositions of generalization—the statements of resemblance and diversity—are true in themselves, and also by the consciousness of power which it imparts, and the feeling of difficulty overcome which it involves. We feel gratified when we have closely followed the brilliant induction which led Newton to the discovery that white is the union of all colours, and when we have accompanied him in the series of profound researches, from the invention of a new calculus or instrument of investigation, through innumerable original geometrical lemmas, to the final demonstration that the force of gravitation deflects the comet from the tangent of its elliptical orbit; and we feel the gratification, because the pursuit of these investigations assures us that the marvellous propositions are indeed true—because there is a consciousness of man's power in being able to penetrate so far into the secrets of nature, and search so far into the structure of the universe—and because there is a pleasure, which we enjoy individually, in having accomplished a task of considerable difficulty. In these gratifications, derived from the contemplation and the investigation of general laws, consists the Pleasure of Science properly so called, and apart from all views of deriving particular advantages from its application to man's use.

This *pleasure is increased* as often as we find that any scientific discovery is susceptible of practical applications. The contemplation of this adaptation is pleasing, independent of any regard to our own individual advantage, and even though we may desire never to be in a condition to reap benefit from it. We sympathize, perhaps, with those who may be so unfortunate as to require the aid afforded by such applications to relieve and assuage pain; but the mere knowledge that such a corollary follows from the discovery of the scientific truth is pleasing. Of course the gratification is increased, if we know that individually we shall profit by it, and we may perhaps always more or less contemplate this possibility; but this is a pleasure, properly speaking, of a different kind from that which science, as such, bestows.

The branch of science which we are here particularly considering differs in no respect from the other departments of philosophy in the kind of gratification which it affords to those who cultivate it. Natural Theology, like the other sciences, whether physical or mental, bestows upon the student the pleasures of contemplation — of generalization; and it bestows this pleasure in an eminent degree. To trace design in the productions and in the operations of nature, or in those of the human understanding, is, in the strictest sense of the word, generalization, and consequently produces the same pleasure with the generalizations of physical and of psychological science. Every part of the foregoing reasoning, therefore, applies closely and rigorously to the study of Natural Theology. Thus, if it is pleasing to find that the properties of two curves so exceedingly unlike as the ellipse and the hyperbola closely resemble each other, or that appearances so dissimilar as the motion of the moon and the fall of an apple from the tree are different forms of the same fact, it affords a pleasure of the same kind to discover that the light of the glow-worm and the song of the nightingale are both provisions of nature for the same end of attracting the animal's mate, and continuing its kind—that the peculiar law of attraction pervading all matter, the magnitude of the heavenly bodies, the inclination of the planes they move in, and the directions of their courses, are all so contrived as to make their mutual actions, and the countless disturbances thence arising, all secure a perpetual stability to the system which no other arrangement could attain. It is a highly pleasing contemplation of the self-same kind with those of the other sciences to perceive everywhere design and adaptation—to discover uses even in things apparently the most accidental—to trace this so constantly, that where peradventure we cannot find the purpose of nature, we never for a moment suppose there was none, but only that we have hitherto failed in finding it out—and to arrive at the intimate persuasion that all seeming disorder is harmony — all chance, design—and that nothing is made in vain. Nay, things which in our ignorance we had overlooked as unimportant, or even complained of as evils, fill us afterwards with contentment and delight, when we find that they are subservient to the most important and beneficial uses. Thus inflammation and the generation of matter in a wound we find to be the effort which Nature makes to produce new flesh, and effect the cure; the opposite hinges of the valves in the veins and arteries are the means of enabling the blood to circulate; and so of innumerable other arrangements of the animal economy. So, too, there is the highest gratification derived from observing that there is a perfect unity, or, as it has been called, a *personality*, in the kind of the contrivances in which the universe abounds; and truly this peculiarity of character or of manner, as other writers have termed it, affords the same species of pleasure which we derive from contemplating general resemblances in the other sciences.

We may close this branch of the subject with the observation *that those* other sciences have often in their turn derived aid from Natural Theology, at least from the speculation of Final Causes, for which they, generally speaking, lay the foundation. Many discoveries in the physiology both of animals and plants owe their origin to some arrangement or structure being remarked, the peculiar object of which was not known, and the ascertaining of which led to the knowledge of an important truth. The well-known anecdote of Harvey, related by Mr. Boyle, is the best example of this which can be given. In his tract on Final Causes he thus writes: "I remember that when I asked our famous Harvey, in the only discourse I had with him, (which was but a while before he died), what were the things that induced him to think of a circulation of the blood, he answered me, that when he took notice that the valves in the veins of so many parts of the body were so placed that they gave free passage to the blood towards the heart, but opposed the passage of the venal blood the contrary way, he was incited to imagine that so provident a cause as Nature had not so placed so many valves without design, and no design seemed more probable than that since the blood could not well, because of the interposing valves, be sent by the veins to the limbs, it should be sent through the arteries, and return through the veins whose valves did not oppose its course that way."* Even the arts have borrowed from the observation of the animal economy. Those valves—the hollow bones of birds—the sockets of the joints—have all furnished suggestions upon which some of our most useful machinery is constructed. Nor can any abuse arise from this employment of the argument, so long as we take care only to let it occupy the subordinate place of a suggestor—an originator of inquiry—and never suffer it to usurp the station of a sole guide, or a substitute for that induction which alone can be relied on in forming

* Disquisition about the Final Causes of Natural Things.—*Works, vol. v. p. 427,—4to.*

our conclusions. The ancients were ignorant of this caution, and would probably have rested satisfied with the consideration which only set Harvey upon making experiments, instead of proving in this way what the argument from Final Causes only rendered próbable. Hence much of what, as we have already explained, Lord Bacon has said upon the subject of this speculation, abused as it certainly has been in all ages, but especially in ancient times.

SECTION II.

OF THE PLEASURE AND IMPROVEMENT PECULIAR TO NATURAL THEOLOGY.

HITHERTO we have only shown that the gratification which the contemplation of scientific truth is calculated to bestow belongs to Natural Theology in common with the other branches of philosophy. But there are several considerations which make it plain that the pleasure must be greater which flows from the speculations of this than any which the other sciences confer.

In the *first* place, the nature of the truths with which Natural Theology is conversant is to be considered. They relate to the evidences of design, of contrivance, of power, of wisdom, of goodness, but let us only say of design or contrivance. Nothing can be more gratifying to the mind than such contemplations: they afford great scope to the reasoning powers; they exercise the resources of our ingenuity; they give a new aspect to the most ordinary appearances; they impart life, as it were, to dead matter; they are continually surprising us with novel and unexpected proofs of intentions plainly directed to a manifest object. If some scoffers and superficial persons despise the enthusiasm with which these investigations have at times been pursued, and hold the exercise given by them to the ingenuity of inquirers to be rather a play of imagination than of reasoning, it is equally undeniable that in some of the most important and most practically useful of the sciences, design, so far from being a matter of fanciful conjecture, is always assumed as incontestable, and the *inquiry*, often with a merely practical view, is confined to discovering what the object of the design is. Thus, when the physiologist has discovered some part of the animal body before unknown, or observed some new operation of the known organs, he never doubts that design exists, and that some end is to be answered. This he takes for granted without any reasoning; and he only endeavours to find out what the purpose is—what use the part can have—what end the operation is intended to accomplish; never supposing it possible that either the part could be created, or the function appointed, without an object. The investigation conducted upon the assumption of this postulate has frequently led to the most brilliant discoveries—among others, as we have just seen, to by far the most important ever made in physiological science. For the mere exercise of the intellectual faculties, or gratification of scientific curiosity, we may refer to almost all the singular phenomena which form the bases of the reasonings as to design—the structure of the ear, and still more of the eye—the circulation of the blood—the physiology of the fœtus in the womb, as contrasted with the economy of the born animal, and the prospective contrivances of a system which, until the birth, is to be wholly useless—the structure of the eye and the nictitating membrane in different birds, and the haw in certain quadrupeds—the powers of the eye in birds of prey—perhaps more than anything else, the construction of their cells by bees, according to the most certain principles discovered by men only with the help of the most refined analytical calculus. The atheist can only deny the wonderful nature of such operations of instinct by the violent assumption that the bee works as the heavenly bodies roll, and that its mathematically correct operations are no more to be wondered at than the equally mathematically adjusted movements of the planets—a truly violent assumption, and especially of those who angrily deny that men have a soul differing in kind from the sentient principle in the lower animals.

Secondly. The universal recurrence of the facts on which Natural Theology rests deserves to be regarded as increasing the interest of this science. The other sciences, those of Physics at least, are studied only when we withdraw from all ordinary pursuits, and give up our meditations to them. Those which can only be prosecuted by means of experiment can never be studied at all without some act of our own to alter the existing state of things, and place nature in circumstances which force her by a kind of question, as Lord Bacon phrases it, to reveal her secrets. Even the sciences which depend on observation have their fields spread only here and there, hardly ever lying in our way, and not always accessible when we would go out of our way to walk in them. But there is no place where the evidences of Natural Religion are not distributed in ample measure. It is equally true that those evidences continually meet us in all the other branches of science. A discovery made in these almost certainly involves some new proofs of design in the formation and government of the universe.

Thirdly and chiefly. Natural Theology stands far above all other sciences from the sublime and elevating nature of its objects. It tells of the creation of all things—of the mighty power that fashioned and that sustains the universe—of the exquisite skill that contrived the wings, and beak, and feet of insects invisible to the naked eye—and that lighted the lamp of day, and launched into space comets a thousand times larger than the earth, whirling a million of times swifter than a cannon ball, and burning with a heat which a thousand centuries could not quench. It exceeds the bounds of material existence, and raises us from the creation to the Author of Nature. Its office is, not only to mark what things are, but for what purpose they were made by the infinite wisdom of an all-powerful Being, with whose existence and attributes its high prerogative is to bring us acquainted. If we prize, and justly, the delightful contemplations of the other sciences; if we hold it a marvellous gratification to have ascertained exactly the swiftness of the remotest planets — the number of grains that a piece of lead would weigh at their surfaces—and the degree in which each has become flattened in shape by revolving on its axis; it is surely a yet more noble employment of our faculties, and a still higher privilege of our nature, humbly, but confidently, to ascend from the universe to its Great First Cause, and investigate the unity, the personality, the intentions, as well as the matchless skill and mighty power of Him who made and sustains and moves those prodigious bodies, and all that inhabit them.

Now, all the gratification of which we have been treating is purely scientific, and wholly independent of any views of practical benefit resulting from the science of Natural Theology. The pleasure in question is merely that double gratification which every science bestows—namely, the contemplation of truth, in tracing resemblances and differences, and the perception of the evidence by which that truth is established. Natural Theology gives this double pleasure, like all other branches of science—like the mathematics—like physics —and would give it if we were beings of an order different from man, and whose destinies never could be affected by the truth or the falsehood of the doctrines in question. Nay, we may put a still stronger case, one analogous to the instance given above of the pleasure derived from contemplating some fine invention of a surgical instrument. Persons of such lives as should make it extremely desirable to them that there was no God, and no Future State, might very well, as philosophers, derive gratification from contemplating the truths of Natural Theology, and from following the chain of evidence by which these are established, and might, in such sublime meditation, find some solace to the pain which reflection upon the past and fears of the future are calculated to inflict upon them.

But it is equally certain that the science derives an interest incomparably greater from the consideration that we ourselves, who cultivate it, are most of all concerned in its truth—that our own highest destinies are involved in the results of the investigation. This, indeed, makes it, beyond all doubt, the most interesting of the sciences, and sheds on the other branches of philosophy an interest beyond that which otherwise belongs to them, rendering them more attractive in proportion as they connect themselves with this grand branch of human knowledge, and are capable of being made subservient to its uses. See only in what contemplations the wisest of men end their most sublime inquiries! Mark where it is that a Newton finally reposes after piercing the thickest veil that envelopes nature—grasping and arresting in their course the most subtle of her elements and the swiftest—traversing the regions of boundless space—exploring worlds beyond the solar way—giving out the law which binds the universe in eternal order! He rests, as by an inevitable necessity, upon the contemplation of the Great First Cause, and holds it his highest glory to have made the evidence of his existence, and the dispensations of his power and of his wisdom, better understood by men.

If such are the peculiar pleasures which appertain to this science, it seems to follow that those philosophers are mistaken who would restrict us to a very few demonstrations, to one or two instances of design, as sufficient proofs of the Deity's power and skill in the creation of the world. That one sufficient proof of this kind is, in a certain sense, enough cannot be denied: a single such proof everthrows the dogmas of the atheist, and dispels the doubts of the sceptic; but is it enough to the gratification of the contemplative mind? The great multiplication of proofs undeniably strengthens our positions; nor can we ever affirm respecting the theorems in a science not of necessary but of contingent truth, that the evidence is sufficiently cogent without variety and repetition. But, independently altogether of this consideration, the gratification is renewed by each instance of design which we are led to contemplate. Each is different from the other. Each step renews our delight. The finding that at every step we make in one science, and with one object in view, a new proof is added to those before possessed by another science, affords a perpetual source of new interest and fresh enjoyment. This would be true if the science in question were one of an ordinary description. But when we consider what its nature is —how intimately connected with our highest concerns — how immediately and necessarily leading to the religious adoration of the Supreme Being—can we doubt that the perpetually renewed proofs of his power, wisdom, and goodness tend to fix and to transport the mind, by the constant nourishment thus afforded to feelings of pure and rational devotion? It is, in truth, an exercise at once intellectual and moral, in which the highest faculties of the understanding and the warmest feelings of the heart alike partake, and in which not only without ceasing to be a philosopher the student feels as a man, but in which the more warmly his human feelings are excited, the more philosophically he handles the subject, What delight can be more elevating, more truly worthy of a rational creature's enjoyment, than to feel, wherever we tread the paths of scientific inquiry, new evidence springing up around our footsteps—new traces of divine intelligence and power meeting our eye! We are never alone; at least, like the old Roman, we are never less alone than in our solitude. We walk with the Deity; we commune with the Great First Cause, who sustains at every instant what the word of his power made. The delight is renewed at each step of our progress, though as far as evidence is concerned we have long ago had proof enough. But that is no more a reason for ceasing to contemplate the subject in its perpetually renovated and varied forms, than it would be a reason for resting satisfied with once seeing a long-lost friend, that his existence had been sufficiently proved by one interview. Thus, instead of restricting ourselves to the proofs alone required to refute atheism or remove scepticism, we should covet the indefinite multiplication of evidences of design and skill in the universe, as subservient in a threefold way to purposes of use and of gratification: *first,* as strengthening the foundation whereupon the system reposes; *secondly,* as conducive to the ordinary purposes of scientific gratification: each instance being a fresh renewal of that kind of enjoyment; and *thirdly,* as giving additional ground for devout, pleasing, and wholesome adoration of the Great First Cause who made and who sustains all nature.

It is, therefore, manifest that, instead of resting satisfied with details and reasons barely sufficient to prove the existence of design in the universe, the gratification of a laudable scientific curiosity, and the proper indulgence of rational devotion, require that every occasion should be taken of exhibiting those evidences upon which the system of Natural Theology rests. The professed treatises upon that science do not suffice for this purpose, although they ought unquestionably to enter largely, and with very great variety of illustration, into the proofs; but each several branch of science, natural and moral, should have a constant reference to this, and should never fail to apply its peculiar doctrines towards the proof and the illustration of the doctrines of Natural Theology.

SECTION III.

ON THE CONNEXION BETWEEN NATURAL AND REVEALED RELIGION.

The ordinary arguments against Natural Theology with which we have to contend are those of atheists and sceptics; of persons who deny the existence of a First Cause, or who involve the whole question in doubt; of persons who think they see a balance of reason for denying the existence of a Deity, or who consider the reasons on both sides as so equally poised that it is impossible to decide either way. An objection of a very different nature has sometimes proceeded, unexpectedly, from a very different quarter — the friends of Revelation—who have been known, without due reflection, to contend that by the light of unassisted reason we can know absolutely nothing of God and a Future State. They appear to be alarmed lest the progress of Natural Religion should prove dangerous to the acceptance of Revealed; lest the former should, as it were, be taken as a substitute for the latter. They argue as if the two systems were rivals, and whatever credit the one gained, were so much lost to the other. They seem to think that if any discovery of a First Cause and another world were made by natural reason, it would no longer be true that "life and immortality were brought to light by the gospel." Although these reasoners are neither the most famous advocates of revelation, nor the most enlightened, we yet may do well to show the groundlessness of the alarms which they would excite.

1. In the *first* place, it is worthy of our consideration

that the greatest advocates of Natural Theology have always been sincere and even zealous Christians. The names of Ray, Clarke, Derham, Keill, Paley, attest the truth of this assertion. None of these was likely to lend his support to any system, the evidence of which put the out-works of Christianity in jeopardy. Some of them, as Clarke and Paley, have signalized themselves as strenuous and able defenders of the truth of Revelation. Derham actually delivered his celebrated work on the great truths of Natural Theology as a series of sermons preached in Bow Church, at a Lecture for the promotion of the Christian religion, founded by Mr. Boyle. At the same Lecture, in St. Paul's, was delivered Dr. Clarke's argument *à priori*, and indeed his whole "Evidence of Natural and Revealed Religion," as well as his "Demonstration of the Being and Attributes of God;" and Dr. Bentley, the first preacher upon that foundation, delivered in like manner as sermons his argument in favour of Natural Religion from the structure of the human mind, the animal body, and the universe at large.

This Lecture was expressly founded by Mr. Boyle in support of the Christian religion; and no reference to Natural Theology, apart from its uses in supporting Revelation, is to be found in the terms of the gift. The subject of the eight sermons is to be, in the words of the will, "The proof of the Christian religion against notorious infidels, viz. atheists, theists, Pagans, Jews, and Mahometans, not descending lower to any controversies that are among Christians themselves." Yet the great Christian divines whom we have named so construed these words as to include a proof of Natural Religion among the most essential arguments for Christianity; and almost as many of the sermons preached at the Boyle Lecture, during the first forty years after its foundation, relate to the doctrines of Natural Theology as to those of Revelation. So far were the divines of that day from holding the two subjects as hostile to each other.*

2. But, *secondly*, Natural Theology is most serviceable to the support of Revelation. All the soundest arguments in behalf of the latter presuppose the former to be admitted. Witness the profound work of Butler, his 'Analogy of Natural and Revealed Religion to the Order of Nature,' the most argumentative and philosophical defence of Christanity ever submitted to the world. But Lardner and Paley, and all other writers on the same side, abound in references to Natural Theology, and in the course of their reasonings assume its truth as postulates.

We may suppose that those practised controversialists and zealous Christians did not make such assumptions gratuitously. We may safely give them credit for not resting their case upon more postulates than the exigency of the argument required. Such a course, if unnecessary, should have been most unskilful, and might have proved dangerous by opening the door to new attacks. But they are not peculiar in their view of the subject. Boyle and Newton were as sincerely attached to Christianity as any men in any age, and they are likewise the most zealous advocates of Natural Religion. Lord Bacon, though imbued perhaps with a certain degree of predjudice on this subject, but of a philosophical and not a polemical origin, distinctly places the truth of Natural Religion at the entrance of theological study, and regards the evidences of Revelation as founded upon the previous demonstration of Natural Theology. "The latter," he says, "is the key of the former, and opens our understanding to the genuine spirit of the Scriptures, but also unlocks our belief, so that we may enter upon the serious contem-

* If any one will read the vituperation rather than sermon against infidels with which Dr. Bentley commences his discourses upon Natural Religion, he will see no reason to doubt the zeal for Christianity of that most learned preacher.

plation of the divine Power, the characters of which are so deeply graven in the works of the creation."* He elsewhere also lays it down as clear that atheism is to be refuted not by miracles but by the contemplation of nature, and accurately takes the distinction between Revelation and Natural Religion; that the former declares the will of God as to the worship most acceptable, while the latter teaches his existence and powers, but is silent as to a ritual.†

3. Accordingly we proceed a step farther, and assert, *thirdly*, that it is a vain and ignorant thing to suppose that Natural Theology is not necessary to the support of Revelation. The latter may be untrue, though the former be admitted. It may be proved, or allowed, that there is a God, though it be denied that he ever sent any message to man, through men or other intermediate agents; as indeed the Epicureans believed in the existence of the gods, but held them to keep wholly aloof from human affairs, leaving the world, physical as well as moral, to itself, without the least interference in its concerns.‡ But Revelation cannot be true if Natural Religion is false, and cannot be demonstrated strictly by any argument, or established by any evidence, without proving or assuming the latter. A little attention to the subject will clearly prove this proposition.

Suppose it were shown by incontestable proofs that a messenger sent immediately from heaven had appeared on the earth; suppose, to make the case more strong against our argument, that this messenger arrived in our own days, nay appeared before our eyes,

* De Dig. et Aug. lib. i. † De Dig. lib. iii. c. 2.

‡ It is singular, too, that this sect inculcated religious duties towards the gods, whom nevertheless they neither believed to be the creators nor governors of the universe. Cicero says of its founder, "De sanctitate, de pietate adversus deos libros scripsit Epicurus. At quomodo in his loquitur? ut Coruncanum, ut Scævolam, pontifices maximos, te audire dicas."—["Epicurus wrote two books on holiness and piety towards the Gods: but how does he speak of them? As you might suppose you were listening to Coruncanus, to Scævola, our high-priests."]—"You would think," says he, "to hear him, it was our high-priests descanting upon holiness and piety."

and showed his divine title to have his message believed by performing miracles in our presence. No one can by possibility imagine a stronger case; for it excludes all arguments upon the weight or the fallibility of testimony; it assumes all the ordinary difficulties in the way of Revelation to be got over. Now, even this strong evidence would not at all establish the truth of the doctrine promulgated by the messenger; for it would not show that the story he brought was worthy of belief in any one particular except his supernatural powers. These would be demonstrated by his working miracles. All the rest of his statement would rest on his assertion. But a being capable of working miracles might very well be capable of deceiving us. The possession of power does not of necessity exclude either fraud or malice. This messenger might come from an evil as well as from a good being; he might come from more beings than one; or he might come from one being of many existing in the universe. When Christianity was first promulgated, the miracles of Jesus were not denied by the ancients; but it was asserted that they came from evil beings, and that he was a magician. Such an explanation was consistent with the kind of belief to which the votaries of polytheism were accustomed. They were habitually credulous of miracles and of divine interpositions. But their argument was not at all unphilosophical. There is nothing whatever inconsistent in the power to work miracles being conferred upon a man or a minister by a supernatural being, who is either of limited power himself, or of great malignity, or who is one of many such beings. Yet it is certain that no means can be devised for attesting the supernatural agency of any one, except such a power of working miracles; therefore, it is plain that no sufficient evidence can ever be given by direct Revelation alone in favour of the great truths of religion. The messenger in question might have power to work miracles without end, and yet it would remain unproved, either that God was omnipotent, and one, and benevolent, or that he destined his creatures to a future state, or that he had made them such as they are in their present state. All this might be true, indeed; but its truth would rest only on the messenger's assertion, and upon whatever internal evidence the nature of his communication afforded; and it might be false, without the least derogation to the truth of the fact that he came from a superior being, and possessed the power of suspending the laws of nature.

But the doctrines of the existence of a Deity and of his attributes, which Natural Religion teaches, preclude the possibility of such ambiguities and remove all those difficulties. We thus learn that the Creator of the world is one and the same; and we come to know his attributes, not merely of power, which alone the direct communication by miracles could convey, but of wisdom and goodness. Built upon this foundation, the message of Revelation becomes at once unimpeachable, and invaluable. It converts every inference of reason into certainty, and, above all, it communicates the Divine Being's intentions respecting our own lot with a degree of precision which the inferences of Natural Theology very imperfectly possess. This, in truth, is the chief superiority of Revelation, and this is the praise justly given to the Gospel in sacred writ—not that it teaches the being and attributes of God, but that it brings life and immortality to light.

It deserves, however, to be remarked, in perfect consistency with the argument which has here been maintained, that no mere Revelation, no direct message, however avouched by miraculous gifts, could prove the faithfulness of the promises held out by the messenger, excepting by the slight inference which the nature of the message might afford. The portion of his credentials which consisted of his miraculous powers could not prove it. For unless we had first ascertained the unity and the benevolence of the being that sent him, as those miracles only prove power, he might be sent to deceive us; and thus the hopes held out by him might be delusions. The doctrines of Natural Religion here come to our aid, and secure our belief to the messenger of one Being, whose goodness they have taught us to trust.

4. In other respects, the services of Natural Religion are far from inconsiderable, as subsidiary to, and co-operative with, the great help of revelation. Thus, were our whole knowledge of the Deity drawn from Revelation, its foundation must become weaker and weaker as the distance in point of time increases from the actual interposition. Tradition, or the evidence of testimony, must of necessity be its only proof: for perpetual miracles must be wrought to give us evidence by our own senses. Now, a perpetual miracle is a contradiction in terms; for the exception to, or suspension of, the laws of nature so often repeated would destroy the laws themselves, and with the laws the force of the exception or suspension. Upon testimony, then, all Revelation must rest. Every age but the one in which the miracles were wrought, and every country but the one that witnessed them—indeed, all the people of that country itself save those actually present—must receive the proofs which they afford of Divine interposition upon the testimony of eye-witnesses, and of those to whom eye-witnesses told it. Even if the miracles were exhibited before all the nations of one age, the next must believe upon the authority of tradition, and if we suppose the interposition to be repeated from time to time, each repetition would incalculably weaken its force, because the laws of nature, though not wholly destroyed, as they must be by constant violation, would yet lose their prevailing force, and each exception would become a slighter proof of supernatural agency. It is far otherwise with the proofs of Natural Religion; repetition only strengthens and extends them. We are by no means

affirming that Revelation would lose its sanction by lapse of time, as long as it had the perpetually new and living evidence of Natural Religion to support it. We are only showing the use of that evidence to Revelation, by examining the inevitable consequences of its entire removal, and seeing how ill supported the truths of Revelation would be, if the prop were withdrawn which they borrow from Natural Theology; for then they would rest upon tradition alone.*

In truth, it is with Natural Religion as with many of the greatest blessings of our sublunary lot: they are so common, so habitually present to and enjoyed by us, that we become insensible of their value, and only estimate them aright when we lose them, or fancy them lost. Accustomed to handle the truths of Revelation in connexion with, and in addition to, those of Natural Theology, and never having experienced any state of mind in which we were without the latter, we forget how essential they are to the former. As we are wont to forget the existence of the air we constantly breathe until put in mind of it by some violent change threatening suffocation, so it requires a violent fit of abstraction to figure to ourselves the state of our belief in Revelation were the lights of natural religion withdrawn. The existence and attributes of a God are so familiarly proved by everything around us, that we can hardly picture to ourselves the state of our belief in this great truth, if we only knew it by the testimony borne to miracles, which, however authentic, were yet wrought in a remote age and distant region.†

5. The use of Natural Theology to the believer in Revelation is equally remarkable in keeping alive the feelings of piety and devotion. As this topic has occurred

* Note V.

† Mr. Locke has said, upon a similar question, "He that takes away Reason to make way for Revelation puts out the light of both; and does much about the same as if he would persuade a man to put out his eyes, the better to receive the remote light of an invisible star by a telescope."—*Human Understanding*, iv. 19, 4.

under a former head, it is only to be presented here in close connexion with Revealed Religion. It may be observed, then, that even the inspired penmen have constant recourse to the views which are derived from the contemplation of nature when they would exalt the Deity by a description of his attributes, or inculcate sentiments of devotion towards him. "How excellent," says the Psalmist, "is thy name in all the earth; thou hast set thy glory above the heavens. I will consider the heavens, even the work of thy fingers; the moon and the stars which thou hast ordained." See also that singularly beautiful poem the 139th Psalm; and the Book of Job, from the 38th to the 41st chapter.

It is remarkable how little is to be found of particularity and precision in anything that has been revealed to us respecting the nature of the Godhead. For the wisest purposes it has pleased Providence to veil in awful mystery almost all the attributes of the Ancient of Days beyond what natural reason teaches. By direct interposition, through miraculous agency, we become acquainted with his will, and are made more certain of his existence; but his peculiar attributes are nearly the same in the volume of Nature and in that of his Revealed word.*

* Archbishop Tillotson has pronounced an authoritative opinion in favour of Natural Religion, as essential to the proof of Revealed. His admirable Sermons abound in such statements—thus, in the 41st, "Unless we be first firmly persuaded of the providence of God, and of his particular care of mankind, why should we suppose that he makes any revelation of his will to us? Unless it be first naturally proved that God is a God of truth, what ground is there for believing his word? So that all religion is founded upon right notions of God and his perfections, insomuch that Divine Revelation itself does suppose these for its foundation, and can signify (*i.e.* disclose or reveal) nothing to us unless they be first known and believed." "So that the principles of Natural Religion are the foundations of that which is revealed." This sermon was preached before the King and Queen (William and Mary) on the Thanksgiving for the naval victory in 1692. The sermon on Steadfastness in Religion, one of the archbishop's great masterpieces, and in which he demonstrates against Rome the right of private judgment, tallies with the 41st in the doctrine on Natural Religion.

NOTES.

Note I.—Page 9.

Of the Classification of the Sciences.

I am abundantly sensible, not only, as is stated in the text, how imperfect all such classifications must be, but that grave objections may be urged against the one I have adopted, and particularly against the threefold division of *physical*, *psychological*, and *ethical* or *moral*. It may be said that one part of the moral branch of Natural Theology belongs to psychology—namely, the arguments drawn from the nature of the mind in favour of a future state; and that this part ought therefore to have been classed with the second division of the ontological branch—namely, the psychological. But it must be borne in mind that the two first divisions, comprising the ontological branch, are confined to the doctrine of existences—the investigation of the Deity's existence and attributes; while the whole of the third division, or second branch, relates to the prospects of man with respect to his soul; and consequently, although the arguments respecting these prospects are partly of a psychological nature, yet they relate to the future, and not at all to the past or present —not at all to the doctrine of existence or attributes. This is therefore a sufficiently distinct ground for the separation. In all such classifications we should be guided by views of convenience, rather than by any desire to attain perfect symmetry; and that arrangement may be best suited to a particular purpose which plants the same things in one order, and separates them and unites them in one way, when an arrangement which should dispose those things differently might be preferable, if we had another purpose to serve. Thus the three divisions of physics, psychology, and morals may be convenient for the purposes of Natural Theology, and yet it may not so well suit the purposes of general science; although I own my opinion to be in favour of that classification for such general purposes also, keeping always in mind that whatever portion of moral science (using the term in its more ordinary sense) belongs to ontology comes within the second, and not the third, subdivision, and that the third deals with deontology alone.

The various classifications which, in ancient as well as modern times, have been made of the sciences, are well calculated to illustrate the difficulty of a perfect arrangement. The Greek philosophers distinguished them into physics, ethics, and logic. Under the first head was comprehended both the nature of mind and of the Deity; consequently, under physics were classed what we now term psychology and theology, as well as natural philosophy. Mr. Locke mainly adopted the same order when he ranged the objects of science into *physical*, *practical*, and *logical* (φυσικη, πρακτικη, σημειωτικη, or λογικη); or, 1. Things in themselves knowable, whether God himself, angels, spirits, bodies; or their affections, as number, figure, &c. 2. Actions, as they depend upon us in order to happiness; and 3. The use of signs, in order to knowledge. Thus, like the Greek philosophers, he classed natural philosophy, psychology, and theology under one head; but as he only stated ethics to be "the most considerable of the second head," it may be doubtful whether or not he included under it any practical application of the natural branches of the first head. One thing, too, is quite clear in this arrangement,—that pure mathematics becomes part of the science of ontology, that is, of existences, natural and mental; and yet it bears a more close relation to the third, or logical division. It certainly appears somewhat violent to class fluxions with anatomy, metallurgy with psychology, and entomology with theology; while we make separate heads of ethics and logic. But yet more violent is M. Turgot's classification, by which he ranges, under the head of physical sciences, not only natural philosophy and metaphysics by name, but also logic and history. To thus classing history there is, indeed, a double objection. Not only is it doing unnecessary violence to common language, to make that which bears no exclusive relation to natural objects a part of physics, but to make history a science at all is perhaps yet more objectionable, unless in the sense in which inductive science is deemed historical by Lord Bacon—being considered by him as the history of facts. But this, too, is incorrect; for the history or record of facts is only the foundation of inductive science, which consists in the comparison, or reasoning from the comparison, of these facts, and marking their differences and resemblances; whereas history is applicable to all events and all sciences, being merely the record of things that have happened, of whatever kind, and implies no reasoning or comparing at all. Why is poetry, music, painting, omitted in such an arrangement as that of Turgot? They are as much sciences as history.

Lord Bacon's own scientific classification is certainly not distinguished by peculiar felicity. He divides science into three parts, according as its object is the Deity, Man, or External Nature, naming these branches—Natural Theology, Human Philosophy, and Natural Philosophy. Hence, while intellectual and moral philosophy are separated from theology, they are both classed with anatomy and medicine; while optics and acoustics, merely from their relation to the human eye and the human ear, are ranged under the same head with ethics, and separated from natural philosophy. Hence, too, the chemical nature of the blood and bones of man is made one part of one division—Human Philosophy: while the chemical nature of the blood and bones of all other animals is ranged under another head—Natural Philosophy. As for logic and the mathematics, they are treated as a kind of appendix to physics, rather than as deserving the name of sciences.

Note II.—Page 37.

Of the Psychological Argument from Final Causes.

Dr. Clarke maintains that the evidences of design are much more to be traced in the natural than in the moral world; but he plainly means by this proposition, not so much to compare the proofs of Divine wisdom exhibited in the phenomena of the material with those exhibited in the phenomena of the intellectual world, as to show that the designs or intentions of the Deity are more easily perceived in the arrangements of the world with which we are most conversant, than his plans for our happiness, and his general intentions respecting our fate, are to be inferred from moral considerations. It is, however, to be remarked that, like all other reasoners upon Natural Theology, Dr. Clarke confines his attention entirely to physical, and never adverts to psychological, proofs.

Mr. Smith, in his 'Theory of Moral Sentiments,' has interspersed with his reasonings upon the constitution of the affections and feelings, reflections upon the purposes to which they are subservient; and Mr. Stewart's writings afford frequent instances of his attention having been alive to the soundness of the same speculation. Indeed, no one who had the accurate and just views of the nature of the sentient principle, and the steady conviction of its separate and immaterial nature, which prevail through all his writings, could fail to perceive the application of the argument *à posteriori* to our mental constitution. But these indications of this admirable writer's attention to the subject are accidental, and scattered through his works; and it is exceedingly to be regretted, nor, indeed, very easily to be explained, that he should have entirely omitted all reference to the constitution of our mental faculties in the otherwise full and able treatise upon Natural Religion which forms so large a part—above one-third—of his 'Philosophy of the Active Powers.' With the exception of a single remark (vol. ii. p. 48), and that only upon the adaptation of our faculties to our external circumstances, and a quotation from Locke, which relates more to the bodily than to the mental powers, there occurs nothing whatever upon this important part of the subject in that excellent work, where it would have been so peculiarly appropriate.

This silence of modern writers upon Natural Theology is easily accounted for by the same consideration to which Dr. Reid has referred in explaining how the modern sceptics have admitted the existence of appearances of design in the universe, and denied what he terms the major proposition —that design may be traced by its effects; while the ancient sceptics, admitting the latter proposition denied the former. He considers this as owing to the great discoveries in physics made in modern times; and to the same cause may be ascribed the disposition of Natural Theologians to confine their attentions to the evidences afforded by the material world. The ancients, on the other hand, whose progress in Natural Philosophy was extremely limited, bestow more attention, and with considerably greater success, upon Intellectual Philosophy; and accordingly we find that they drew their arguments *à posteriori* for the existence of design in the universe as much from moral as from physical considerations.

The discussion held by Socrates with Aristodemus, as recorded by

Xenophon, is well known. After enumerating the various convenient arrangements of the bodily organs, he adds—*Ου τοινυν μονον ηρκεσε τῷ θεῷ του σωματος επιμεληθηναι· αλλ' (όπερ μεγιστον εστι) και την ψυχην κρατιστην τῷ ανθρωπῷ ενεφυσε· τινος γαρ αλλου ζωου ψυχη πρωτα μεν θεων, των τα μεγιστα και καλλιστα συνταξαντων, ησθηται ότι εισι; τι δε φυλον αλλο η ανθρωποι, θεους θεραπευουσι; ποια δε ψυχη της ανθρωπινης ἱκανωτερα προφυλλαττεσθαι, η λιμον, η διψος, η ψυχη, η θαλπη, η νοσοις επικουρησαι, η ῥωμην ασκησαι, η προς μαθησιν εκπονησαι, η όσα αν ακουσῃ, η ιδῃ, η μαθῃ, ἱκανωτερα εστι διαμεμνησθαι;*—"*Nor has the Deity been satisfied with taking care of the body alone; he has implanted in man what is a far greater work to have made—a most excellent soul; for what other animal possesses a mind that can perceive the existence of the Gods by whom all these vast and fair works have been formed? What other creature than man worships those Gods? What other intelligence is superior to man's in providing against hunger, and thirst, and cold, and heat? or in curing diseases, or in exercising strength, or in cultivating learning, or in storing up the recollection of things heard, and seen, and learnt?*"*—It may be observed here, in passing, that Mr. Stewart, who refers to this passage, has adopted the pharaphrastic translation by Mrs. Fielding, and it is extremely unlike the original. Mr. Stewart justly praises the "almost divine simplicity" of the whole conversation, which is a just eulogy; but the translation, although well written, little resembles the Greek in that particular. The one I have here given is at least faithful.

In like manner, the discussion with Euthydemus, after showing the goodness of the Gods in adapting all things to man's use, closes with mentioning the senses given us to enjoy those gifts of external nature, and, lastly, the use of reason. *Το δε και λογισμον ἡμιν εμφυσαι*, &c., &c.—"*They have implanted reason in our nature, whereby we inquire touching external things; and arguing and remembering, we learn the use of each, and hit upon many contrivances for attaining good and avoiding evil. Have they not also given us the gift of speech, by which we can communicate mutually all we have learnt, and thus instruct each other, and make laws, and regulate civil polity?*"†

Plato pursues the same course of reasoning. We may refer particularly to the tenth and twelfth books of the treatise 'De Legg.' Thus, towards the end of the latter book, he states the argument for the Deity's existence as twofold—the nature of the mind, and the order of the worldly system. The first of his reasons is drawn from considering the qualities of the mind; its greater antiquity than that of the body, and its immortality; for the Platonists certainly considered immortality to be so much of the essence of mind as to deduce from thence, as the less clear proposition, the existence of a Deity.

The Stoics reasoned in like manner, with an equal regard to mental and to natural phenomena. Epictetus, after deducing the inference of design from the adaptations of sensible objects, as of the eye to light, adds, correctly and philosophically, that "the constitution of the understanding, whereby it not only receives impressions through the senses, but also deals with the ideas thus received, and combines or composes something out of them, proceeding from things that are near to things quite remote, proves

* Xen. Memor. I. iv. 13.

† Xen. Memor. IV. iii. 11.

the existence of an Artificer; since things carrying such marks of contrivance could not," he contends, "exist spontaneously, and without design." *

The same train of reasoning is followed by Cicero in all those parts of his writings in which he treats of the existence of a Deity. Thus the famous passage so often quoted from the treatise 'De Natura Deorum,' ends with a reference to our mental constitution, although this part of it is not so frequently attended to. "An vero si domum magnam pulchramque videris, non possis adduci ut, etiamsi dominum non videas, muribus illam et mustelis ædificatam putes; tantum vero ornatum mundi, tantam varietatem pulchritudinemque rerum cœlestium, tantam vim et magnitudinem maris atque terrarum, si tuum ac non deorum immortalium domicilium putes, nonne plane desipere videare?"—"If you should see a large and handsome house, you could not be induced, though you saw no master, to suppose that it was built for mice and weasels; but such is the embellishment of the world, such the variety and beauty of the heavens, such the force of the ocean and magnitude of the earth, that if you supposed them formed for the habitation of man rather than the immortal gods, you would obviously seem to be insane." Thus far as to sensible objects. But he proceeds, "Aliud a terrâ sumsimus, aliud ab humore, aliud ab igne, aliud ab aëre, eo quem spiritû ducimus: illud autem quod vincit hæc omnia, rationem dico, et si placet, pluribus verbis, mentem, consilium, cogitationem, prudentiam, ubi invenimus? unde sustulimus?" †—"Whatever we take from earth, from water, from fire, from air, differs from what we obtain from the spirit; but that which surpasses all things, reason I mean, or if you please, in other words, mind, judgment, thought, prudence, where do we find it? whence can we obtain it?"

And again, in the same book, after speaking at large on the structure of the body, and the uses to which its various parts are adapted, he adds, "Jam vero animum ipsum mentemque hominis, rationem, consilium, prudentiam, qui non divinâ curâ perfecta esse perspicit, is his ipsis rebus mihi videtur carere."—"He who does not perceive that the soul and mind of man, reason, judgment, prudence, have been made perfect by divine care, seems to me to be deficient in these very things." He proceeds to show how great a gift reason is from its productions: "Ex quo scientia intelligitur quam vim habeat, qualis sit, quâ ne in deo quidem est res ulla præstantior."—"From which knowledge we may understand its power, which is, indeed, such that there is nothing more excellent even in God himself." And he closes with the well-known passage in praise of eloquence.‡

In the Tusculan Questions he alludes to mind in a different manner. After going through the various provisions made for human enjoyment in the economy of nature, he adds, "Sic mentem hominis, quamvis eam non videas, ut deum non vides; tamen, ut deum agnoscis ex operibus ejus, sic ex memoriâ rerum et inventione et celeritate motus omnique pulchritudine virtutis, vim divinam mentis agnoscito." §—"Thus, though you cannot see the mind of man, as you cannot see God, yet as you acknowledge God from his works, so, from memory and invention, from the celerity of

* Epict. Enchir. i. 6.

† De Nat. Deor. ii. 6.

‡ Ibid. ii. 59.

§ Tusc. Qu. i. 28.

its movements and the excellence of its qualities, you acknowledge the divine power of the mind."

The course of the argument in which he is engaged in this first part of his work, the immortality of the soul, leads him to use the phenomena of its faculties for the purpose of illustrating its separate existence; and, therefore, he only enumerates the arrangements of the natural world as proofs of Divine agency, and gives those proofs not as the main object of the argument, but as introductory to his statement of the soul's independent nature.

In these speculations of the ancient philosophers, we cannot find any process of strict inductive reasoning; and, accordingly, the facts are not turned to the best account for the purposes of the argument. But this defect appears, at the least, as much in the physical as in the psychological portion of the reasoning. Indeed, the latter comes more near to our own philosophy; and certainly we must admit that those old writers upon Natural Theology, in the place which they assign to intellectual phenomena, pursued a more sound and consistent method of philosophizing, than the moderns have done when speculating upon the same subject.

Note III.—Page 54.

Of the Doctrine of Cause and Effect.

The argument deduced by sceptical writers from Mr. Hume's doctrine respecting causation has tended to bring some discredit upon the doctrine itself, by raising a prejudice against it. The bad use, however, which is made of a sound principle is not fairly a matter of charge against that principle. The only question is whether or not the principle be just in itself; and it cannot be just if legitimate reasoning can deduce from it an absurd consequence. A dangerous consequence, how rigorously soever following from it, would of course form no reason against its reception, though it might justly be made the ground of examining very narrowly the foundations upon which the doctrine itself rested.

Mr. Stewart, in a valuable and learned note to the 'Philosophy of the Human Mind' (vol. i., note D), has brought together the authorities, which have all more or less not only countenanced, but even forestalled Mr. Hume in his position—that we know nothing of causation except by observing a constant junction between two events or two facts. This is unquestionably true. We expect that heat being applied to combustible bodies, they will take fire; and that air being excluded they will cease to burn. We expect this, because between the application of heat and the ignition of the heated body, between the exclusion of air and the extinction of the fire, we have constantly observed the relation of sequence—the one event being always followed closely by the other. The inference which forms the ground of this expectation, forms the ground of our belief that the one event occasions the other—that there is between the two a connexion beyond the mere relation of junction and sequence—and that the one, the preceding event, exerts an influence, a force, a power, over the other, and produces the other.

This constant conjunction, therefore, in point of fact, is the ground of our belief, and is the origin of our ideas of causality or causation. So far we must admit the doctrine in question. That it is the only ground of the belief, and the only origin of the idea, may admit of some doubt. This is the point on which turns the connexion between the science of Natural Theology and the controversy we are now referring to; and therefore it deserves some consideration in the present note.

1. The mere constant and unvarying succession of two events would not of itself be sufficient to make us, even in popular language, denominate the one a cause of the other. Light uniformly succeeds dark—one o'clock always follows twelve; but no man ever thought of calling or of deeming night to be the cause of day, or noon of afternoon.* Another and a very important experiment or observation is required before we pronounce the successive or conjoined events to be related one to the other as cause and effect. Not only must the second event always have been found to follow the first, but the second must never have been observed without the first preceding it, or at least without some other event preceding it—in which case the causation is predicated alike of both those preceding events. Thus, the clock pointing to one is not reckoned the effect of its having previously pointed to twelve; but it is reckoned the effect of a certain mechanism, namely, a spring unfolding itself, because if the spring is prevented from relaxing, the hand no longer points; and so it is also reckoned the effect of a weight pulling a cord, because, when that weight is stopped in its descent, the whole machinery stops.

2. But we derive not our notion of causality, from even this double proof—the positive and negative combined—the two observations that one event always follows the other, and that it ceases when the other ceases. This of itself would only tell us the fact, that when one event exists the other exists immediately afterwards and not otherwise. Our minds form, whether we will or no, another idea—not merely that of constant connexion or succession, but of the one exerting a power over the other by an inherent force; and this is the idea of causation. Whence do we derive it? I apprehend only from our consciousness. We feel that we have a will and a power—that we can move a limb, and affect by our own powers, excited after our own volition, a change upon external objects. Now fromthis consciousness we derive the idea of power, and we transfer this idea and the relation on which it is founded between our own will and the change produced, to the relations between events wholly external to ourselves—assuming them to be connected, as we feel our volition and our movements are mutually connected.

If it be said that this idea by no means involves that of necessary connexion, nothing can be more certain. The whole is a question of fact—of contingent truth. Just as the world might be so constituted that heat applied should not ignite, nor air excluded extinguish—so might our volition cease to make our limbs move, as it does cease in paralysis. As it is,

* Mr. Stewart's observation, that day follows night as much as night follows day, makes no difference in this illustration: for we may suppose the case of a person seeing day for the first time, or twelve o'clock for the first time, and the conclusion in the text would still hold good.

and because our will has hitherto had the power to move our limbs, we have acquired the idea of power and of causation. But if it had always been otherwise, and that no connexion of succession had ever existed between our volition and our movements, I do not see how the idea of power or causality could ever have been obtained by us from any observation of the sequence of events. The idea of design or contrivance, in like manner, must have been wanting to us; and hence, I cannot understand how, but for the consciousness of power, we could ever have been led to the belief in the existence of a First Cause. This is another, and to my mind, a very strong, additional reason for resting the evidences of Natural Theology upon the argument *à posteriori* alone.

That they are greatly in error who confound, as has been too common, causation with necessary connexion, and who deny the existence of the relation of causality merely because the relation is contingent and not necessary, is sufficiently manifest. Our ideas of power and of causation are solid and well founded, although they only refer to a power or a causation which may or may not exist. That one event causes another, may be a proposition quite true, to which we affix a precise and definite meaning, and which we have learnt from observation and from consciousness, although the order of nature might easily have been so constituted as that the two events should never have been found in sequence. At present the order of nature connects them, and we affirm that there exists the relation of cause and effect—a relation contingent, however, and not necessary. Of necessary causation, we can by no possibility know anything; but causation may be real enough though contingent.

NOTE IV.—PAGE 40, 53.

Of the 'Système de la Nature,' and the Hypothesis of Materialism.

THERE is no book of an atheistical description which has ever made a greater impression than the famous 'Système de la Nature.' It bears the impression of London, 1780, but was manifestly printed in France; also, it purports to be written by Mirabaud, secretary of the Académie Française; and in a prefatory advertisement by the supposed editor, who pronounces a great panegyric upon the work, enough appears to engender doubts of Mirabaud having been its author. He died in 1760; and it was twenty years before the work appeared—found, says the writer, among a collection of manuscripts made by a "savant curieux de rassembler des productions de ce genre." Robinet, the author of another work of similar tendency, called 'De la Nature,' has been at different times said to be its author, without any proof, or indeed probability; but the general opinion now ascribes it to the Baron d'Holbach, aided, in all probability, by Diderot, Helvetius, and other members of the freethinking society, who frequented the Baron's house, and who used to complain of Voltaire's excess of religious principle, not unfrequently ridiculing him for his fanaticism. Mirabaud, upon whom this publication most unjustifiably charges the book, by placing his name in the title-page without any doubt expressed, and reserving the doubts for the preface, was a man of unimpeachable integrity and amiable disposition. He had been educated in the College of the Jesuits, and afterwards was preceptor to some branches of the royal family; he died at the age of eighty-five, universally esteemed for his unblemished character, his strict probity, and his attractive manners. The Diderots and Grimms, though not perhaps persons of abandoned life, were very far from attaining such praise: indeed, the licentious works that proceeded from Diderot's pen attest his deficiency, at least in one branch of morals.

It is impossible to deny the merits of the 'Système de la Nature.' The work of a great writer it unquestionably is; but its merit lies in the extraordinary eloquence of the composition, and the skill with which words substituted for ideas, and assumptions for proofs, are made to pass current not only for arguments against existing beliefs, but for a new system planted in their stead. As a piece of reasoning, it never rises above a set of plausible sophisms—plausible only as long as the ear of the reader being filled with sounds, his attention is directed away from the sense. The chief resource of the writer is to take for granted the thing to be proved, and then to refer back to his assumption as a step in the demonstration, while he builds various conclusions upon it, as if it were complete. Then he declaims against a doctrine seen from one point of view only, and erects another for our assent, which, besides being liable to the very same objections, has also no foundation whatever to rest upon. The grand secret, indeed, of the author goes even farther *in petitione principii* than this; for we oftentimes find, that in the very substitute which he has provided for the notions of belief he would destroy, there lurks the very idea which he is combating, and that his idol is our own faith in a new form, but masked under different words and phrases.

The truth of these statements we are now to examine; but first it may be fitting to state why so much attention is bestowed upon this work. The reason is, that its bold character has imposed on multitudes of readers, seducing some by its tone of confidence, but intimidating others by its extreme audacity. It is the only* work of any consideration wherein atheism is openly avowed and preached—avowed, indeed, and preached in terms. (See, particularly, Part ii., chap. ii.) This effect of its hardihood was certainly anticipated by its author; for the supposed editor, in his advertisement, describes it somewhat complacently, if not boastingly, as "l'ouvrage le plus hardi et le plus extraordinaire que l'esprit humain ait osé produire jusqu'à présent."—["The most audacious and extraordinary work which the human mind has hitherto dared to produce."]

The grand object of the book being to show that there is no God, the author begins by endeavouring to establish the most rigorous materialism, by trying to show that there is no such thing as mind—nothing beyond or different from the material world. His whole fabric is built on this foundation; and it would be difficult to find in the history of metaphysical controversies such inconclusive reasoning, and such undisguised assumptions of the matter in dispute as this fundamental part of his system is composed of. He begins with asserting that man has no means of carry-

* The treatise of Robinet, *De la Nature*, which, though far less eloquent and dexterous, is superior in real merit, has never attracted anything like the same notice.

ing his mind beyond the visible world; that he is necessarily confined within its limits; and that there exists nothing, and there can exist nothing, beyond the boundary which encloses all beings—that is, the material world. Nature, we are told, acts according to laws, simple, uniform, invariable, which we discover by experience. We are related to Universal Nature by our senses, which alone enable us to discover her secrets; and the instant we abandon the lessons which those senses teach us, we plunge into an abyss where we become the prey of imagination.

Thus the very first chapter—the opening of the work—has already made the gratuitous assumption of a being whom the author calls Nature, without either defining what that is, or how we arrive at a knowledge of its existence. He has also assumed another existence, that of matter, or the material world; and then he asserts—what is absolutely contrary to every day's experience, and to the first rudiments of science—that we know, and can know, nothing but what our senses tell us. It is a sufficient answer to ask, how we know anything of mathematical truth? And in case a cavil should arise upon geometrical science (though it would be but a cavil) we shall speak only of analytical; and then it is certain that the whole science of numbers, from the rules of elementary arithmetic up to the highest branches of the modern calculus, could by possibility have been discovered by a person who had never in his life been out of a dark room—who had never touched any body but his own—nay, whose limbs had all his life been so fixed, that he had never exercised even upon his own body the sense of touch: indeed, we might even go so far as to say, who had never heard a sound uttered; for the primitive ideas of number might by possibility have suggested themselves to his mind, and been made the grounds of all further calculations. What becomes now of all our knowledge depending on the senses? But we need not go to so extreme a case as the one just put: there would be an end of the position we are dealing with, if a person so circumstanced could have discovered any one analytical or common arithmetical truth. Enough, indeed, is known to every one, how moderately soever imbued with mathematical learning, to satisfy him how little the intimations received from the senses have, or can have, to do with the whole science of number and quantity. That those intimations of the senses are themselves not at all of a material nature, we shall presently see.

After many discussions and much eloquence, in the course of which various agents are introduced besides Nature, as Necessity, Relation, and so forth, without definition of their qualities or proof of their existence,—we come to the great demonstration that no soul, no mind, nothing separate from the body and from matter, exists, or indeed can exist: for this book is not content with scepticism; it rests not even satisfied with disproof; it affects to show the impossibility of the doctrines which it combats; and while perpetually complaining of dogmas, it is perhaps the most dogmatical work that was ever written. The sixth and seventh chapters, but the seventh especially, treat of this fundamental doctrine—the corner-stone of the whole building. The argument is, in fact, a mere vague and unintelligible combination of words, as when the author concludes by saying, The result of the whole is, that "the soul, far from being anything distinguishable from the body, is only the body itself regarded relatively to some of its functions, or to some of the manners of acting or of being, whereof it is capable as long as it enjoys life"—("n'est que ce corps lui-même envisagé relativement à quelqu'unes de ses fonctions ou à quelques façons d'être et d'agir dont il est susceptible tant qu'il jouit de la vie"). Or when he describes those faculties which are vulgarly called intellectual, as modes or manners of being and of acting, which result from the organization of the body—("les facultés que l'on nomme intellectuelles ne sont que des modes ou des façons d'être et d'agir résultant de l'organisation de notre corps.")—Part i., chap. viii.

But there is still more to be remarked throughout the Treatise, an inconceivable forgetfulness of the evidence on which each party in the controversy most relies, a constant assumption of the thing in question, and even an involuntary assumption of that very separate and spiritual existence which it is the author's object to disprove.

Like all materialists, but far more grossly and dogmatically than almost any other, the author begins by assuming that Matter exists, that we can have no doubt whatever of this, and that any other existence is a thing to be proved. Now, what is this matter? Whence do we derive any knowledge of it? How do we assure ourselves of its existence? What evidence at all have we respecting either its being or its qualities? We feel, or taste, or smell something—that is, we have certain sensations which make us conclude that something exists beyond ourselves. It will not do to say beyond our bodies; for our bodies themselves give us the same sensations. What we feel is something beyond, or out of, or external to, or other than and apart from, *ourselves*—that is, from our minds. Our sensations give us the intimation of such existences. But what are our sensations? The feelings or thoughts of our minds. Then what we do is this: From certain ideas in our minds, produced no doubt by, and connected with, our bodily senses, but independent of, and separate from them, we draw certain conclusions by reasoning, and those conclusions are in favour of the existence of something other than our sensations and our reasonings, and other than that which experiences the sensations and makes the reasonings—passive in the one case—active in the other. That something is what we call Mind. But plainly, whatever it is, we owe to it the knowledge that Matter exists: for that knowledge is gained by means of a sensation or feeling, followed by a process of reasoning; it is gained by the mind having first suffered something, and then done something, and, therefore, to say there is no such thing as Matter would be a much less absurd inference than to say there is no such thing as Mind. The very act of inferring, as we do by reasoning, that the object which affects our senses exists apart from ourselves, is wholly incapable of giving us any knowledge of the object's existence without, at the same time, giving us a knowledge of our own—that is, of the Mind's existence. An external implies necessarily an internal; that there may be anything beyond or without, there must needs be some other thing beyond or without which it is said to exist; that there may be a body which we feel abiding separate from us, namely, our own body, one part of which gives us sensations through another part—there must be a *we*, an *us*—that is, a *mind*. If, as the 'Système de la Nature' often contends, we have a right to call spirit, or soul, or Mind, a mere negation of the qualities of Matter, surely this might just as well be retorted by saying, that Matter is only a negation of the qualities of Mind. But, in truth, the materialists cannot stir one step without the aid of that Mind whose existence they deny.

Then what are those *qualities* of Matter they are always speaking about? What but the effects, or the power of causing those effects produced by Matter upon the Mind through the senses? A remarkable instance, and a very instructive one, of the impossibility of a materialist arguing legitimately, strictly, or consistently, is to be found in the passage of this book, where the argument is as it were summed up against the existence of mind: "La matière seule peut agir sur *nos sens*, sans *lesquels* il *nous* est impossible que rien se fasse *connoître de nous*."—"Matter alone can act upon our senses, without which it is impossible that anything can become known to us." Here the author, in order to deny the possibility of Mind, or anything else than Matter having an existence, uses, in two lines, expressions, six times over, all drawn from the assumption of a something existing separate from and independent of Matter. *Our—senses—which—us—known—by us*—all these are words absolutely without meaning if there is nothing but matter in existence; and these are expressions conveying the ideas of which this fundamental proposition wholly consists. But that the author refers to Bishop Berkeley, as well as Mr. Locke, it might have been supposed that he had never been made aware of the controversy upon the existence of matter. Indeed the manner in which he mentions the speculations of Berkeley is quite sufficient to show his ignorance of the nature of the question, and reminds us forcibly of the remark made by D'Alembert, that whoever had not at times doubted the existence of matter, might be assured he had not any genius for metaphysical inquiries. Would any one believe it possible, that an author who could dogmatically deny the possibility of Mind existing in any form apart from Matter, should be so little competent to discuss questions like this, as to speak in these terms of Berkeley? "Que disons nous d'un Berkeley qui s'efforce de nous prouver que tout dans ce monde n'est qu'une illusion chimérique; que l'univers entier n'existe que dans nous-mêmes, et dans notre imagination," &c. "Pour justifier des opinions si monstrueuses," &c.—"What shall we say of a Berkeley who endeavours to prove to us that everything in the world is a chimerical illusion; that the whole universe only exists in ourselves and in our imagination? To justify opinions so monstrous," &c.

The truth is, that we believe in the existence of Matter, because we cannot help it. The inferences of our reason from our sensations impel us to this conclusion, and the steps are few and short by which we reach it. But the steps are fewer and shorter, and of the self-same nature, which lead us to believe in the existence of Mind; for of that we have the evidence within ourselves, and wholly independent of our senses. Nor can we ever draw the inference in any one instance of the existence of matter without at the same time exhibiting a proof of the existence of mind; for we are, by the supposition, reasoning, inferring, drawing a conclusion, forming a belief; therefore there exists somebody, or something, to reason, to infer, to conclude, to believe; that is, *we*—not any fraction of matter, but a reasoning, inferring, believing being—in other words, a Mind. In this sense the celebrated argument of Descartes—*cogito, ergo sum*—had a correct and a profound meaning. If, then, scepticism can have any place in our system, assuredly it relates to the existence of Matter far more than of Mind; yet the 'Système de la Nature' is entirely founded upon the existence of Matter being a self-evident truth, admitting of no proof, and standing in need of none.

We have combated the main body of the argument which runs through the whole book, and passed over some of the gross errors. apparently proceeding from ignorance of physical science, in which it abounds. Of these the most notable, no doubt, is that which Voltaire, in his 'Essai sur le Système de la Nature,' considers (chap. i.) as the foundation of the whole theory—the absurd passage respecting the formation of eels. Certain it is, that in the Second chapter of Part I., the experiment of moistening flour, and thereby producing live microscopic insects, is referred to as a proof that "inanimate matter can pass into life," "which," adds the book, "is itself but the union of notions." No one indeed can accuse Voltaire of taking an unfair advantage when he relies on this piece of extraordinary ignorance; but it is not altogether just to represent the whole book as resting on this blunder.

As for the kind of comparisons or analogies by which, like all materialists, this writer tries to illustrate his hypothesis, and by which many materialists really are deceived—the mechanism of a watch, for example, consisting of parts each separately incapable of producing any result, but altogether forming a moving instrument that measures the efflux of time—nothing, surely, can be more puerile than the attempt to draw from thence an argument in favour of the confused, and, when examined closely, unintelligible position that Mind is a modification of Matter, or the result of a collocation of material particles. For the watch is material, doubtless, both in its whole and in each part separately; the combination never produces any effect that is not strictly of a material kind; the motions and the registration of time resulting from them are all as purely mechanical as the form of each part, and each part has in it every quality and incident in kind which the whole possesses. The difference in the case of Mind is, that we have something wholly of a new and peculiar kind, and in no respect resembling or belonging to the same class with any of the exertions or operations of the material parts, the combination of which is alleged by the materialist to have given it birth.

The First Part having laid the foundation by disproving the existence of Mind, the second part of the 'Système' proceeds to raise upon it the conclusion that the Deity's existence is impossible. This part is much more declamatory than the former, though often displaying great powers of eloquence, and reminding us of the more striking parts of Rousseau's early writings, especially his paradoxes against knowledge, perhaps in a more choice style, and with colouring more subdued. But reasoning it contains absolutely none, with the exception of the Fourth chapter, where Dr. S. Clarke's argument *à priori* is dissected and refuted—a task, unfortunately, not very difficult to accomplish, though it is here done in an illegitimate manner. We cannot, however, fail to observe, that while the author proposes to go through the arguments of the various philosophers who have maintained the existence of a Deity; and while he does remark on Descartes, Malebranche, Newton, and Clarke (in a chapter which forms by far the most argumentative part of his book), he never approaches those who have treated the question by the argument *à posteriori*. In one place (chap. vii.) he refers to Final Causes, but this passage only relates to the subject of man's superiority and the arguments of the optimists, and does not at all touch upon the evidences of design derived from the structure of the universe—the great foundation of Natural Theology. It is impossible to suppose the author ignorant of the argument *à posteriori*, for he in one place refers to Derham by name. The omission of all reference to the most important branch of the subject is one of the things that most bring the good faith of this writer into question.

The purpose of this note having been to show how the atheistical argument grounded on materialism fails when examined in its connexion with the evidences of the Mind's independent existence, to pursue farther the Second Part of the work is unnecessary. But a few remarks are added to show how exactly the same assumption of the things to be proved prevails here which we observed in the First Part.

The first proposition, and supported at great length, is that all the ideas which man has formed of a First Cause have resulted from the evils of his lot, and that but for human suffering a Deity would never have been thought of. "Inquiry and speculation," says the author, "is itself an evil; and no creature living easy and happy, without pain and without wants, would ever give himself the trouble and annoyance of arguing on a First Cause. But fear and evil, especially pain and death—the terrors of earthquake, eclipse, tempest—the horrors of death—drove the mind to seek out the source of all these dangers, and to appease or disarm its supposed wrath; and thus the sky was peopled with gods and spirits."

Now, that the fears and the ignorance of men have been the fruitful source of polytheism, no one doubts; but it is wholly false to assert that genuine and philosophical religion could have had no other origin. To affirm that, but for their sufferings and fears, men never would have encountered the pain or the trouble of speculating on a First Cause, is quite contrary to the most obvious facts. Those speculations, far from being painful or troublesome, are gratifying in the highest degree. As well might it be said that all the pleasures of scientific discovery and study would have been foregone by all men, but for some physical inconvenience that drove them into those paths of investigation. Of all writers, the authors of the great improvements in physical science are they who have been the least under the pressure of want, and have gained the least by their labours. But such speculations are productive of the greatest gratification, both to the guide who originally points out the way, and to those who more humbly follow in his footsteps. So the sublime contemplations of Natural Theology have engaged men's attention and exercised their faculties, wholly independent of any sufferings they were exposed to, or any fears they entertained; and far from being a source of pain, this study has ever been found to reward its votaries with the purest enjoyment.

That the study and the knowledge of a Deity would have existed without any relation to evil is therefore clear. Man's curiosity—his natural desire of tracing the origin of what he saw around him—his anxiety to know whence he came, and whither he was going, and how the frame of the universe was contrived and sustained—would have led to the study and knowledge of a Creator without any such motives as this book supposes.

It is remarkable, that in the latter, as in the former portion of the work, blind assumptions are not only always made, but an entire disregard is shown to the evidence which often arises out of those very assumptions, and proves the truths its author is endeavouring to subvert. Thus, in the Second chapter, he says: "Whether the human race has always existed on this earth, or that it is a recent and transitory production of nature. . . . . ." Now, if it be a recent production of nature, surely this admits the creative power—the very divinity the book is contending against; for what can be the meaning of a state of things, in which, up to a certain time—*i.e.* six or seven thousand years ago—the human species had no existence, and then the species coming into existence, or, as the book says, being produced by nature? What but that a superintending power, which had not before acted in this way, now for the first time began thus to act? To call this Nature is only changing the name—a Deity is the plain and the true meaning, and the only thing which can be meant.

Indeed, nothing can be more absurd and unreflecting than the play made throughout the book with mere words. Thus, in the same chapter, it is asked—whether a Theologian "can really be sincere in believing himself to have made a step by substituting the vague words, spirit, incorporeal substances, divinity, &c., for those intelligible words"—what? what words so much less vague and more intelligible* than spirit?—"those intelligible words, matter, nature, mobility, necessity!" Now, we may safely ask, if all language furnishes two words more vague and less intelligible than two out of those four—viz. nature and necessity? But we have, in truth, already shown, that Matter, as far as the present controversy is concerned, offers no more precise idea to our contemplation than Mind or spirit, and that its existence and qualities rest on less conclusive evidence than do those of Mind. Possibly the reader of this passage, and especially if he casts his eye back upon the former parts of the argument, may be inclined to adopt the writer's description of Theology, and apply it to the dogmatical Atheism of the 'Système de la Nature.'

* There occurs everywhere in this book a vague and mysterious idea of a force or living power belonging to Matter, and almost a *deification* of this power, utterly unintelligible; but in a hater of Deity—a derider of all gods—quite marvellous. The passage in which this idea is most strikingly announced is the 11th chapter of part ii., where he is answering the position that there is no such a thing as an Atheist in the world.—"Si par *Athée* l'on désigne un homme qui nieroit l'existence d'une *force inhérente à la nature* et sans laquelle l'on ne peut concevoir *la Nature*, et si c'est à cette force motive qu'on donne le nom de *Dieu*, il n'existe point d'Athées, et le mot sous lequel on les désigne, n'annonceroit que des fous."—"If by Atheist is meant a man who would deny the existence of a force inherent in Nature, and without which Nature cannot be conceived, and if it is to that moving force that the name God is given, then there are no Atheists, and the word by which they are designated is applicable only to fools."—Can any one doubt, that after rejecting all reasonable and consistent notions of a Deity, this writer had really made unto himself other gods, and bowed down before them, and worshipped them?—For what is "the force inherent in matter?" and what is "nature," and the essence of nature, or that thing "without which nature cannot be conceived?"

Note V.—Page 134.

Of Mr. Hume's Sceptical Writings, and the Argument respecting Providence.

The two most celebrated and most dangerous treatises of this great author, upon religious subjects, are those in which he has attacked the foundations of Natural and of Revealed Religion—the 'Essay on Providence and a Future State,' and the 'Essay on Miracles.' Others of his writings have a similar tendency, and more covertly though as surely sap the principles of religion. But the two essays to which we have referred are the most important writings of this eminent philosopher, because they bring his sceptical opinions more directly to bear upon the systems of actual belief.

I. The argument of Tillotson against the doctrine of the Real Presence is stated to have suggested that against the truth or rather the possibility of Miracles; but there is this most material difference between the two questions—that they who assert the Real Presence drive us to admit a proposition contrary to the evidence of our senses, upon a subject respecting which the senses can alone decide, and to admit it by the force of reasonings ultimately drawn from the senses—reasonings far more likely to deceive than they, because applicable to matter not so well fitted for argument as for perception, but reasonings at any rate incapable of exceeding the evidence the senses give. Nothing, therefore, can be more conclusive than Tillotson's argument—that against the Real Presence we have of necessity every argument, and of the selfsame kind with those which it purports to rest upon, and a good deal more besides; for if we must not believe our senses when they tell us that a piece of bread is merely bread, what right have we to believe those same senses, when they convey to us the words in which the arguments of the Fathers are couched, or the quotations from Scripture itself, to make us suppose the bread is not bread, but flesh? And as ultimately even the testimony of a witness who should tell us that he had heard an apostle or the Deity himself affirm the Real Presence, must resolve itself into the evidence of that witness's senses, what possible ground can we have for believing that he heard the divine affirmation, stronger than the evidence which our own senses plainly give us to the contrary?

This is very far from being the case with the argument on Miracles. There, the evidence for and the evidence against do not coincide in kind, but take opposite directions. There, we have not to disbelieve indications of the same nature with those upon which our belief is challenged. The testimony of witnesses is adduced to prove a Miracle, or deviation from the ordinary laws of nature; but, says Mr. Hume, it is more likely that the witnesses should be deceived or should deceive, than that the laws of nature should be broken; and at all events we believe testimony only because it is a law of nature that men should tell the truth. This may very possibly be true; doubtless it is, generally speaking, so likely to be true, that the belief of a miracle is, and ought to be, most difficult to bring about; but at least, it is not like the belief in the Real Presence: it does not at one and the same time assume the accuracy of the indications given by our senses, and set that accuracy at nought;—it does not at once desire us implicitly to trust and entirely to disregard the evidence of testimony, as the doctrine of Transubstantiation calls upon us at once to trust and disregard the evidence of our senses.

There are two answers, however, to which the doctrine proposed by Mr. Hume is exposed, and either appears sufficient to shake it.

First.—Our belief in the uniformity of the laws of nature rests not altogether upon our own experience. We believe no man ever was raised from the dead—not merely because we ourselves never saw it, for indeed that would be a very limited ground of deduction; and our belief was fixed on the subject long before we had any considerable experience—fixed chiefly by authority—that is, by deference to other men's experience. We found our confident belief in this negative position partly, perhaps chiefly, upon the testimony of others; and at all events, our belief that in times before our own the same position held good, must of necessity be drawn from our trusting the relations of other men—that is, it depends upon the evidence of testimony. If, then, the existence of the law of nature is proved, in great part at least, by such evidence, can we wholly reject the like evidence when it comes to prove an exception to the rule—a deviation from the law? The more numerous are the cases of the law being kept—the more rare those of its being broken—the more scrupulous certainly ought we to be in admitting the proofs of the breach. But that testimony is capable of making good the proof there seems no doubt. In truth, the degree of excellence and of strength to which testimony may rise seems almost indefinite. There is hardly any cogency which it is not capable by possible supposition of attaining. The endless multiplication of witnesses—the unbounded variety of their habits of thinking, their prejudices, their interests—afford the means of conceiving the force of their testimony augmented *ad infinitum*, because these circumstances afford the means of diminishing indefinitely the chances of their being all mistaken, all misled, or all combining to deceive us. Let any man try to calculate the chances of a thousand persons who come from different quarters, and never saw each other before, and who all vary in their habits, stations, opinions, interests—being mistaken or combining to deceive us, when they give the same account of an event as having happened before their eyes—these chances are many hundreds of thousands to one. And yet we can conceive them multiplied indefinitely; for one hundred thousand such witnesses may all in like manner bear the same testimony; and they may all tell us their story within twenty-four hours after the transaction, and in the next parish. And yet, according to Mr. Hume's argument, we are bound to disbelieve them all, because they speak to a thing contrary to our own experience, and to the accounts which other witnesses had formerly given us of the laws of nature, and which our forefathers had handed down to us as derived from witnesses who lived in the old time before them. It is unnecessary to add that no testimony of the witnesses whom we are supposing to concur in their relation contradicts any testimony of our own senses. If it did, the argument would resemble Archbishop Tillotson's upon the real presence, and our disbelief would be at once warranted.*

* Prophecy is classed by Mr. Hume under the same head with Miracle—every prophecy being, he says, a miracle. This is not, however, quite correct. A pro-

Secondly.—This leads us to the next objection to which Mr. Hume's argument is liable, and which we have in part anticipated while illustrating the first. He requires us to withhold our belief in circumstances which would force every man of common understanding to lend his assent, and to act upon the supposition of the story told being true. For suppose either such numbers of various witnesses as we have spoken of; or, what is perhaps stronger, suppose a miracle reported to us, first by a number of relators, and then by three or four of the very soundest judges and most incorruptibly honest men we know—men noted for their difficult belief of wonders, and, above all, steady unbelievers in Miracles, without any bias in favour of religion, but rather accustomed to doubt, if not disbelieve—most people would lend an easy belief to any Miracle thus vouched. But let us add this circumstance, that a friend on his death-bed had been attended by us, and that we had told him a fact known only to ourselves—something that we had secretly done the very moment before we told it to the dying man, and which to no other being we had ever revealed—and that the credible witnesses we are supposing inform us that the deceased appeared to them, conversed with them, remained with them a day or two, accompanying them, and to avouch the fact of his reappearance on this earth, communicated to them the secret of which we had made him the sole depositary the moment before his death. According to Mr. Hume, we are bound rather to believe, not only that those credible witnesses deceive us, or that those sound and unprejudiced men were themselves deceived, and fancied things without real existence, but further, that they all hit by chance upon the discovery of a real secret, known only to ourselves and the dead man. Mr. Hume's argument requires us to believe this as the lesser improbability of the two—as less unlikely than the rising of one from the dead; and yet every one must feel convinced, that were he placed in the situation we have been figuring, he would not only lend his belief to the relation, but, if the relators accompanied it with a special warning from the deceased person to avoid a certain contemplated act, he would, acting upon the belief of their story, take the warning, and avoid doing the forbidden deed. Mr. Hume's argument makes no exception. This is its scope; and whether he chooses to push it thus far or no, all Miracles are of necessity denied by it, without the least regard to the kind or the quantity of the proof on which they are rested; and the testimony which we have supposed, accompanied by the test or check we have supposed, would fall within the grasp of the argument just as much and as clearly as any other Miracle avouched by more ordinary combinations of evidence.

phecy—that is, the happening of an event which was foretold—may be proved even by the evidence of the senses of the whole world. Suppose it had one thousand years ago been foretold, that, on a certain day this year, one person of every family in the world should be seized with a particular distemper, it is evident that every family would be at once certain that the event had happened, and that it had been foretold. To future generations the fulfilment would no doubt come within the description of a miracle in all respects. The truth is, that the event happening which was foretold may be compared to the miracle; and Mr. Hume's argument will then be, not that there is anything miraculous in the event itself, but only in its happening after it had been foretold. Bishop Sherlock wrote discourses on this subject, which Dr. Middleton answered: the former denying that prophecy was more exempt from the scope of the sceptical argument than miracles. On the whole, however, it does seem more exempt.

The use of Mr. Hume's argument is this, and it is an important and a valuable one. It teaches us to sift closely and rigorously the evidence for miraculous events. It bids us remember that the probabilities are always, and must always be, incomparably greater against than for the truth of these relations, because it is always far more likely that the testimony should be mistaken or false, than that the general laws of nature should be suspended. Farther than this the doctrine cannot in soundness of reason be carried. It does not go the length of proving that those general laws cannot, by the force of human testimony, be shown to have been, in a particular instance, and with a particular purpose, suspended.

It is unnecessary to add, that the argument here has only been conducted to one point, and upon one ground, namely, to refute the doctrine that a Miracle cannot be proved by any evidence of testimony. It is for those who maintain the truth of any revelation to show in what manner the evidence suffices to prove the Miracles on which that revelation rests. This treatise is not directed to that object; but in commenting upon Mr. Hume's celebrated argument, we have dealt with a fundamental objection to all Revelation, and one which, until removed, precludes the possibility of any such system being established.

II. The 'Essay on Miracles' being supposed by its author sufficient to dispose of Revelation, the 'Essay on Providence and a Future State' appears to have been aimed as a blow equally fatal to Natural Religion. Its merits are, however, of a very superior order. There is nothing of the sarcasm so unbecoming on subjects of this most serious kind, which disfigures the concluding portion of the former treatise. The tone is more philosophic, and the sceptical character is better sustained. There cannot, indeed, be said to prevail through it anything of a dogmatical spirit, and certainly we here meet with none of that propensity to assume the thing in question, to insist upon propositions as proved which have only been enunciated, to supply by sounds the place of ideas, which we remark in the 'Système de la Nature.' On the contrary, the argument, whether sound or not, is of a substantial nature; it is rested on very plausible grounds; and we may the rather conclude that it is not very easily answered, because, in fact, it has rarely, if ever, been encountered by writers on theological subjects. Nevertheless, it strikes at the root of all Natural Religion, and requires a careful consideration.

Mr. Hume does not deny that the reasoning from the appearances and operations of nature to the existence of an intelligent cause is logical and sound; at least he admits this for argument's sake. But he takes this nice and subtle distinction. We are here, he observes, dealing with an agent, an intelligence, a being wholly unlike all we elsewhere see or hitherto have known: our inferences, therefore, must be confined strictly to the facts from whence they are drawn. When we see a foot-mark imprinted on the sand, we conclude that a man has walked there, and that his other foot had likewise left its print, which the waves have effaced. But this inference is not drawn from the inspection of the foot alone; it comes from a previous knowledge of the human body, of which the foot makes a part. Had we never seen that body, or any other that walked on feet, the observation of the mark in the sand could have led to no other conclusion than that some body or thing had been there with a form like the mark. So, when we are to reason from the works of nature to their cause, we are entitled to conclude that a Being exists whose power and skill created them such as we behold them, and consequently that this Being is possessed of skill and power sufficient to contrive and to execute those works—that is, those precise works, and no more. We have no right to infer that this Being has the skill or the power to contrive and create one single blade of grass or grain of sand beyond what we see. It follows, then, that the argument *à posteriori* only leads to the conclusion that a finite and not an infinitely or an indefinitely wise and powerful Being exists: and it further follows that we are left without any evidence of his power (much less of his intention) to perpetuate our existence after death, as well as without any proof of the capacity of the soul to receive such a continuation of being after its separation from the body. This is the sum of the very ingenious, subtle, and original argument of Mr. Hume, affording a mighty contrast to the flimsy sophisms, the declamatory assertions, of the French writers, and giving the Natural Theologian, it must be allowed, a good deal to answer. We have stated it as strongly as we could, in order to meet it fully; and it appears capable of a satisfactory answer.

The whole argument *à posteriori* rests upon the assumption, that if we perceive arrangements made, by means of which certain effects are produced, and if seeing such arrangements among the works of men, we should at once conclude that they were designed to produce those effects, we are entitled to say that the arrangements which we see and which we know not to be the work of man, are the work of an intelligent cause, contriving them for the purpose of producing the effects observed. In truth, such must needs be the assumption on which the argument rests, because we have no other knowledge of what design and contrivance are. They necessarily bear reference to our own nature and the knowledge we have of our own minds, derived from our own consciousness and experience; and of this we have treated in the text, Sec. iii. and iv. of Part i.

If we found anywhere a mechanism of any kind, a watch, for instance, as Paley puts the case, we should at once conclude that some skilful and intelligent being had been there, and had left his works on the spot. We should conclude (indeed this is involved in the former inference) that he was capable of doing what we saw he had done, and that he had intended to produce a particular effect by the exercise of his skill; but we should also conclude that he who could do this could repeat the operation if he chose, and the probability would be that his skill had not been confined to the single exertion of it which we had observed. There is nothing peculiar in the nature of human workmanship or of the human character to make us draw this conclusion. We arrive at it just as we arrive at the inference of design and contrivance; we believe in them because we are wholly unable to conceive such an adaptation without such an intention; and we are equally unable to conceive that any being, or any intelligence, or any power, which had sufficed to perform the operation we see, should be confined to that single exertion. We can conceive no reason whatever why the same power should not be capable of repeating the operation. There is nothing peculiar—no limit—no sufficient reason, of an exclusive nature, why the same power should not be again exercised, and with the same result. All induction proceeds upon similar grounds: it is the generalization of particulars; it is the concluding from a certain limited number of instances to an indefinite number—to any number unless circumstances arise to restrict the generality—to any number where nothing arises to vary or limit the conclusion. We mix an acid and alkali, and form a neutral salt having peculiar properties. We pass a sun-beam or the light of a candle through a prism, and observe the rays separated into lights making certain colours. Why do we conclude from hence that all the acid made by burning sulphur, in what way soever the sulphur was produced or the combustion effected, will be neutralized by soda wheresoever produced and howsoever obtained, and that their union will always make Glauber's salts? Or, that all light, of all kinds, even that obtained by burning newly-discovered bodies, as the metal of potassium, unseen, unknown before the year 1807, will be found resolvable into the seven primary colours? According to Mr. Hume's argument, we have no right to infer that any one portion of acid or alkali, save the one we have subjected to our experiments, or any light save that of the formerly-known combustible bodies, or rather of those classes of them on which we had experimented; nay, of the individuals of those classes which we have burnt, will produce the effects we have experienced in our laboratory, or in our darkened chamber. In other words, according to this argument, all experimental knowledge must stand still, generalizing be at an end, and philosophers be content never to make a single step, or draw one conclusion beyond the mere facts observed by them: in a word, Inductive Science must be turned from a process of general reasoning upon particular facts, into a bare dry record of those particular facts themselves.

If, indeed, it be said that we never can be so certain of the things we infer as we are of those we have observed, and on which our inference is grounded, we may admit this to be true. But no one therefore denies the value of the science which is composed of the inferences. So we cannot be so well assured of the Deity's power to repeat and to vary and to extend his operations, as we are of his having created what we actually observe; and yet our assurance may be quite sufficient to merit entire confidence. Nor will any student of Natural Theology complain if the only result of the argument we are combating be to place the higher truths of the science but a very little lower in point of proof than the inferences of design in the works actually examined. The selfsame difference is to be found in the inferences composing the other branches of inductive science, and it in no perceptible degree lessens our confidence in the inductive method.

It has oftentimes been asked, why we believe that the same result will happen from the same cause acting in the like circumstances—the foundation of all induction; and no answer has ever been given except that we cannot help so believing—that the condition of our being, the nature of our minds—compels us so to believe; and we take this as an ultimate fact incapable of being resolved into any fact more general. Can we help believing that a Being capable of creating what we see and examine, is also capable of exercising other acts of skill and power? Can we avoid believing that the same power which made all the animals and vegetables on our globe suffices to people and provide other worlds in like manner? Again, can we by any effort bring our minds to suppose that this Being's whole skill and power were exhausted by one effort, and that having sufficed to create the universe, it ceases to be effective for any other purpose whatever? The answer is, that we cannot; that we can as soon believe in the sun not rising to-morrow, or in his light ceasing to be differently refrangible.

Much is said in the course of arguments like the present of the word "*infinite*." Whether or not we are able to form any precise idea of that which has no bounds in power or in duration may be another question. But when we see such stupendous exertions of power, upon a scale so vast as far to pass all our faculties of comprehension, and with a minuteness at the same time so absolute, that, as we can on the one hand perceive nothing beyond its grasp, so we are on the other hand unable to find anything too minute to escape its notice, we are irresistibly led to conclude that there is nothing above or below such an agent, and that nothing which we can conceive is impossible for such an intelligence. The argument of Mr. Hume supposes or admits that the whole universe is its work, and that animal life is its creation. We can no more avoid believing that the same power which created the universe can sustain it—that the same power which created our souls can prolong their existence after death—than we can avoid believing that the power which sustained the universe up to the instant we are speaking, is able to continue it in being for a thousand years to come. But indeed Mr. Hume's argument would go the length of making us disbelieve that the Deity has the power of continuing the existence of the creation for a day. We are only entitled, according to this argument, to conclude that the Deity had the power of working the works we have seen and no more. Last spring and autumn we observed the powers of nature in vegetation, that is, we noted the operations of the Deity in that portion of his works, and were entitled, Mr. Hume admits, to infer that he had the skill and the power to produce that harvest from that seed time, but no more. We had, says the argument, no right whatever to infer that the Deity's power extended to another revolution of the seasons. The argument is this, or it is nothing. Confining its scope, as Mr. Hume would confine it, to the universe as a whole, and excluding all inferences as to a future state or other worlds, is wholly gratuitous. The argument applies to all that we have seen of the already past and the actually executed in this universe, and excludes all respecting this same universe which is yet to come; consequently, if it be good for anything, it is sufficient to prove that, although our experience may authorize us to conclude that the Deity has skill and power sufficient to maintain the world in its present state up to this hour, yet that experience is wholly insufficient to prove that he has either skill or power to continue its existence a moment longer. Every one of the topics applied by him to a Future State applies to this. If we have no right to believe that one exertion of skill proves the author of nature adequate to another exertion of a kind no more difficult and only a little varied, we can have no right to believe that one exertion of skill proves him adequate to a repetition of the same identical operation. Now no man living carries or can carry his disbelief so far as this. Indeed such doubts would not only shake all inductive science to pieces, but would put a stop to the whole business of life. And assuredly we may be well contented to rest the truths of Natural Theology on the same foundation upon which those of all the other sciences, as well as the practical conduct of all human affairs, must for ever repose.

Note VI.—Page 63.

Of the Ancient Doctrines respecting Mind.

The opinions of the ancient philosophers upon the nature of the Soul were not very consistent with themselves; and in some respects were difficult to reconcile with the doctrine of its immateriality, which most of them maintained. It may suffice to mention a few of those theories.

Plato and his pupil Aristotle may certainly be said to have held the Soul's immateriality; at least, they maintained that it was of a nature wholly different from the body; and they appear often to hold that it was unlike all matter whatever, and a substance or existence of a nature quite peculiar to itself. Their language is nearly the same upon this subject. Plato speaks of the ουσια ασωματος και νοητη—*a bodiless* or *incorporeal and intelligent being;* and of such existence he says, in one place, τα ασωματα καλλιστα οντα και μεγιστα λογῳ μονον, αλλῳ δε ουδενι σαφως δεικνυται—"*Things incorporeal being the most excellent and the greatest of all, are made manifest by reason alone, and no otherwise.*"—('Politicus.') So again in the 'Cratylus,' he derives σωμα from σωζεσθαι, and represents the body as a prison of the soul, εικονα δεσμωτηριου ειναι ουν της ψυχης αυτο εως ην τα οφειλομενα το σωμα, following herein the doctrine said to have been delivered by Orpheus. Aristotle, too, speaks of a being separable and separated from things perceivable by the senses—ουσια χωριστη και κεχωρισμενη των αισθητων. Nevertheless, these philosophers frequently speak of the soul as being always, and as it were necessarily, connected with matter of some kind or other—αει ψυχη επιτεταγμενη σωματι, τοτε μεν αλλω, τοτε δε αλλῳ. "*The soul is always annexed to a body, sometimes to one and sometimes to another.*"—'De Legg.' x. Thus Aristotle ('De Gener. Anim.' ii. 4), ἡ γαρ ψυχη ουσια σωματος τινος εστι—"*the soul is the substance of some kind of body.*" And in the treatise 'De Anima,' ii. 2, he says—και δια τουτο καλως ὑπολαμβανουσιν, οἱς δοκει μητε ανευ σωματος ειναι μητε σωμά τι ψυχη· σωμα μεν γαρ ουκ εστι, σωματος δε τι—"*Those therefore rightly hold who think that the soul cannot exist without the body, and yet that it is not body; it is not the body, but somewhat of the body.*"

This corporeal connexion is stated by Plutarch, in the 'Quæst Platon.,' still more plainly to have been the Platonic doctrine—ψυχην αει πρεσβυτεραν του σωματος, αιτιαν τε της εκεινου γενεσεως και αρχην·—ουκ αν γενεσθαι ψυχην ανευ σωματος, ουδε νουν ανευ ψυχης· αλλα ψυχην μεν εν σωματι, νουν δε εν τῃ ψυχῃ. "*The soul is older than the body, and the cause and origin of its existence: not that the soul exists without the body, or the understanding without the soul; but that the soul is in the body, and the understanding in the soul.*"

According to these representations and quotations taken together, Plato held the soul to be an immaterial substance, separable from any given body, but incapable of existing without some body or other, and the mind or understanding to be a part of the soul. The residue of the soul was, as we shall afterwards see, its sensitive or mortal portion.

The idea of motion seems to have been intimately connected in their views with mind or spirit, and in so far their doctrines approach those, if we can call them doctrines, of the modern atheists (See Note IV.)—το ἑαυτο κινειν (says Plato), φης λογον εχειν την αυτην ουσιαν ἡνπερ τουνομα, ὁ δη παντες ψυχην προσαγορευομεν; φημι γε—"*You say that the substance* (or *being*) *to which we all give the name of soul, has for its definition 'that which moves itself?' I certainly do say so.*"—'De Legg.' x.

But the same philosophers also held the soul to be an emanation from the Deity, and that each individual soul was a portion of the Divine Essence, or Spirit: consequently they could not mean to assert that the divine essence was inseparable from matter of some kind, but only those portions of that essence which they represented to be severed, and as it were torn off, from the divine mind—συναφεις τῷ θεῷ, ἁτε αυτου μορια ουσια και αποσπασματα.—('Epict.')

Plutarch, in the work already cited, says—ἡ δε ψυχη ουκ εργον εστι του θεου μονον αλλα και μερος· ουδ' ὑπ' αυτου αλλ' απ' αυτου, και εξ αυτου, γεγονεν—"*The soul is not only his work, but a part of himself; it was not created by him, but from him and out of him.*"

Note VII.—Page 63.

Of the Ancient Doctrines respecting the Deity and Matter.

The notions of the Supreme Being entertained by the ancient philosophers were more simple and consistent than their theory of the soul; and but for the belief, which they never shook off, in the eternity of matter, would very nearly have coincided with our own. They give him the very same names, and clothe him apparently in the like attributes. He is not only αθανατος, αφθαρτος, ανωλεθρος—*immortal, incorruptible, indestructible*—but αγεννητος, αυτογενης, αυτοφυης, αυθυποστατος—*uncreated, self-made, self-originating, self-existing.* Ζωον πασαν εχον μακαριοτητα μετ' αφθαρσιας, says Epicurus—"*A Being having all happiness, with an incorruptible nature.*" Again, he is παντοκρατωρ, παγκρατης—*omnipotent, all-powerful;* δυναται γαρ ἁπαντα, says Homer ('Odyss.' ξ)—"*He has the power over all things.*" The creative power is also, in words at least, ascribed to him—κοσμοποιητης, δημιουργος—*the maker of the world, the great artificer.* Aristotle, too, in a very remarkable passage of the 'Metaphysics,' says that God seems to be the cause of all things, and, as it were, a beginning, or principle—Θεος δοκει το αιτιον πασιν ειναι και αρχη τις: and, indeed, by implication, this is ascribed in the terms *uncreated, self-created,* and *self-existing;* for in soundness of reason the being who had no creator, and much more the being who created himself (if we can conceive such an idea), must have created all things else. Nevertheless, such was certainly not so plain an inference of reasoning with the ancients; for whether it be that by αυτοφυης and αυτογενης, they only meant to convey the idea of αγεννητος—of a being uncreated and existing from all eternity—or that they took some nice distinction, to us incomprehensible, between self-creation and the creation of other beings or things—certain it is, that the same philosophers who so described the Deity clung to the notion of matter being also eternal, and co-existent with the supreme power, and that by creator and artificer they rather seem to have meant the arranger of atoms—the power giving form to chaotic matter, than the power calling things into existence. They appear to have been all pressed by the difficulty (and who shall deny it?) of conceiving the act of creation—the act of calling existences out of nothing. Accordingly, the maxim which generally prevailed among most of the Greek sects, and which led to very serious and even practical consequences in their systems, was *ουδεν εκ μη οντος* (or *εξ ουδενος*) *γινεσθαι*—*that nothing is made of what has no existence, or of nothing.* Aristotle represents this as the common opinion of all natural philosophers before him—*κοινην δοξαν των φυσικων.* He says, in another passage ('De Cœlo,' iii. 1), *οἱ μεν αυτων* (*προτερον φιλοσοφησαντες*) *ανειλον ὁλως γενεσιν και φθοραν· ουδεν γαρ ουτε γιγνεσθαι φασιν ουτε φθειρεσθαι των οντων*—"*Some of those (older philosophers) took away* (or *abolished*) *all generation and destruction, for they hold that none of the things which exist are either created or destroyed.*" Nevertheless, it cannot be doubted that the Platonic doctrine was of the same kind, and that Aristotle, in truth, ascribed only a qualified creative power to the Deity. Plutarch's statement of the Platonic doctrine is precise to this point—*βελτιο ουν Πλατωνι πειθομενους τον μεν κοσμον ὑπο θεου γεγονεναι λεγειν και αδειν· ὁ μεν γαρ καλλιστος των γεγονοτων, ὁδε αριστος των αιτιων· την δε ουσιαν και ὑλην, εξ ἡς γεγονεν, ου γινομενην, αλλα ὑποκειμενην αει τῷ δημιουργῳ, εις διαθεσιν και ταξιν αυτης και προς αυτον εξομοιωσιν, ὡς δυνατον ην παρασχειν· ου γαρ εκ του μη οντος γενεσις, αλλ' εκ του μη καλως, μηδ' ἱκανως εχοντος, ὡς οικιας, και ἱματιου, και ανδριαντος*—"*Better then be convinced by Plato, and say and sing that the world was made by God; for the world is the most excellent of all created things, and he the best of all causes. But the substance or matter* (literally *timber*) *of which he made it, was not created, but always lay ready for the artificer, to be arranged and ordered by him; for the creation was not out of nothing, but out of what had been without form and unfit, as a house, or a garment, or a statue are made.*" And thus it seems that when Maker or Creator is used by the Academics, we are rather to regard them as meaning Maker in the sense in which an artificer is said to make or fabricate the object of his art. Εποιησεν ων (says Timæus) *τονδε τον κοσμον εξ ἁπασας τας ὑλας*—*He made the the world of all kinds of matter.*—'De An. Mund.' Indeed, I can in no other way understand that very obscure, and but for some such gloss, contradictory passage of Aristotle, in the first book of the 'Physics,' where he is giving his own doctrine in opposition to the tenets of the elder philosophers on this point—'Ημεις *δε και αυτοι φαμεν γιγνεσθαι μεν ουδεν ἁπλως εκ μη οντος, ὁμως μεντοι γιγνεσθαι εκ μη οντος, οἱον κατα συμβεβηκος· εκ γαρ της στερησεως ὁ εστι καθ' αὑτο μη ον, ουκ ενυπαρχοντος γιγνεται τι. θαυμαζεται δε τουτο και αδυνατον οὑτω δοκει γιγνεσθαι τι εκ μη οντος*—"*We ourselves however say that nothing is absolutely* (or *merely*) *produced from what has no existence, yet that something is produced from that which has no existence as far as regards accidents* (or *accessory qualities*); *for something is produced from privation, which has no existence in itself, and not from anything inherent. But this is wonderful, and seems impossible, that something should be produced out of that which has no existence.*"—('Phys.' i. 8.) Indeed he had said in the same treatise, just before, that all confessed it impossible and inconceivable that *any being could either be created out of nothing, or be utterly destroyed*—εκ μη οντος γινεσθαι τοτε οι εξολλυσθαι ανηνυστον και αῤῥηκτον. (Ib. i. 5.)

Upon the uncreated nature of things—for the doctrine extended to mind as well as to matter—the ancient philosophers founded another tenet of great importance. Matter and soul were reckoned not only uncreated, but indestructible; their existence was eternal in every sense of the word, without end as without beginning: μηδεν εκ του μη οντος γινεσθαι, μηδε εις το μη ον φθειρεσθαι—"*Nothing can be produced out of that which has no existence, nor can anything be reduced to nonentity.*" Such is Diogenes Laertius's account of Democritus' doctrine, or the Atomic principle.

> "Principium hinc cujus nobis exordia sumet,
> Nullam rem e nihilo gigni divinitus unquam." *
> "Huc accedit uti quidque in sua corpora rursum
> Dissolvat natura, neque ad nihilum intereunt res" †—
> "Haud igitur redit ad nihilum res ulla sed omnes
> Discidio redeunt in corpora materiai" ‡—

are the expressions of Lucretius, in giving an account of the Epicurean Philosophy (i. 151, 217, 249), or, as Persius more shortly expresses it,

> "De nihilo nihil, in nihilum nil posse reverti." §—*Sat.* iii. 84.

And it must be admitted that they reasoned with great consistency in this respect; for if the difficulty of comprehending the act of creation out of nothing was a sufficient ground for holding all things to be eternal *à parte ante*—the equal difficulty of comprehending the act of annihilation was as good a ground for believing in their eternity *à parte post*—there being manifestly just as much difficulty, and of the same kind, in comprehending how a being can cease to exist, as how it can come into existence.

From this doctrine mainly it is that the Greek philosophers derive the immortality of the soul, as far as the metaphysical and more subtle arguments for their belief go; and accordingly its pre-existence is a part of their faith as much as its future life, the eternity *ab ante* being as much considered as the eternity *post*. Thus Plato says that "*our soul was somewhere before it existed in the human form, so that also it seems to be immortal afterwards*"—ην που ἡμων ἡ ψυχη πριν εν τῷδε τῷ ανθρωπινῳ ειδει γινεσθαι, ὥστε και ταυτῃ αθανατον τι εοικεν η ψυχη ειναι.—('Phæd.') Nevertheless, it must be admitted that their doctrine of future existence is most unsatisfactory as far as it is thus derived, that is, their psychological argument: and for two reasons—*first*, because it is coupled with the tenet of pre-existence, and having no kind of evidence of that from reasoning, we not only are prone to reject it, but are driven to suppose that our future existence will in like manner be severed by want of recollection from all consideration of personal identity; *secondly*, because, according to the doctrine of the soul being an emanation from the Deity, its future state implies a return to the divine essence, and a confusion with or

* "Hence we assume this principle in the commencement, that there has never been anything divinely formed out of nothing."

† "We come to this conclusion, that Nature resolves everything again into its parts, nor is anything ever reduced to nothing."

‡ "Therefore there is never anything which returns to nothing; but all substances by dissolution return into their parts."

§ "Nothing can come from nothing, nothing return to nothing."

absorption in that supreme intelligence, and consequently an extinction of individual existence; a doctrine which was accordingly held by some of the metaphysical philosophers who maintained a Future State.

In one important particular there was an entire difference of opinion among the ancient philosophers; in truth, so important a difference, that those were held not to be theists, but atheists, who maintained one side of the argument—I mean as to Providence. The Atomists and Epicureans held that there were Gods, and upon the subject of creative power they did not materially differ from those generally called theists; but they denied that these Gods ever interfered in the affairs of the universe. The language of Plato and the other theists upon this subject is very strong; they regard such a doctrine as one of the three kinds of blasphemy or sacrilege; and in the Republic of that philosopher, all the three crimes are made equally punishable with death. The first species is denying the existence of a Deity, or of Gods—*το δε δευτερον, οντας (θεους) ου φροντιζειν ανθρωπον*. "*The second, admitting their existence, but denying that they care for man.*" The third kind of blasphemy was that of men attempting to propitiate the Gods towards criminal conduct, as *Φθονοι* and *αδικηματα*, *slaughters* and *outrages upon justice*, "*by prayers, thanksgivings, and sacrifices—thus making those pure beings the accomplices of their crimes, by sharing with them a small portion of the spoil, as the wolves do with the dogs.*"—'De Legg.' x.*

NOTE VIII.—PAGE 85.

Of the Ancient Doctrine of the Immortality of the Soul.

THAT the ancient philosophers for the most part believed in the Future Existence of the Soul after death is undeniable. It is equally certain that their opinions upon this important subject varied exceedingly, and that the kind of immortality admitted by one class can hardly be allowed to deserve the name. Thus they who considered it as a portion of the Divine essence severed for a time, in order to be united with a perishable body, believed in a future existence without memory or consciousness of personal identity, and merely as a reuniting of it with the Divine mind. Such, however, was not the belief of the more pure and enlightened theists, and to their opinion, as approaching nearest our own, it is proposed to confine the present notice.

* Who can read these, and such passages as these, without wishing that some who call themselves Christians, some Christian Principalities and Powers, had taken a lesson from the heathen sage, and (if their nature forbade them to abstain from massacres and injustice) at least had not committed the scandalous impiety, as he calls it, of singing in places of Christian worship, and for the accomplishment of their enormous crimes, Te Deums, which in Plato's Republic would have been punished as blasphemy? Who, indeed, can refrain from lamenting another pernicious kind of sacrilege (an anthropomorphism) yet more frequent—that of making Christian temples resound with prayers for victory over our enemies, and thanksgiving for their defeat? Assuredly such a ritual as this is not taken from the New Testament.

In one respect, even the most philosophical of those theories differed widely from the Christian faith, and indeed departed almost as widely from the intimations of sound reason. They all believed in the soul's pre-existence. This is expressly given as proved by facts, and as one argument for immortality or future existence, by Plato in the most elaborate treatise which remains upon the subject, the 'Phædo.' He considers that all learning is only recollection, την μαθησιν αναμνησιν ειναι, and seems to think it inconceivable that any idea could ever come into the mind, of which the rudiments had not formerly been implanted there. In the 'Timæus' and other writings the same doctrine is further expounded. Ην που ἡμων ἡ ψυχη πριν εν τῳδε τῳ ανθρωπινῳ ειδει γενεσθαι, ὡστε και ταυτῃ αθανατον τι εοικεν ἡ ψυχη ειναι. "*Our soul existed somewhere before it was produced in the human form* (or *body*) *so that it seems to be immortal also.*" The arguments indeed, generally speaking, on which both Plato and other philosophers ground their positions, derive their chief interest from the importance of the subject, and from the exquisite language in which they are clothed. As reasonings they are of little force or value. Thus it is elaborately shown or rather asserted in the 'Phædo' that contraries always come from contraries, as life from death, and death from life, in the works of Nature. Another argument is that the nature or essence of the soul is immortality, and hence it is easily inferred that it exists after death, a kind of reasoning hardly deserving the name—'Οποτε δη το αθανατον και αδιαφθορον εστιν, αλλο τὶ ψυχη, η ει αθανατος τυγχανει ουσα, και ανωλεθρος αν ειη—"*Since that which is immortal is also indestructible, what else can we conclude but that the soul being* (or *happening to be*) *immortal, must also be imperishable?*"—'Phæd.' A more cogent topic is that of its simplicity, from whence the inference is drawn that it must be indestructible, because what we mean by the destruction of matter is its resolution into the elements that compose it. In one passage Plato comes very near the argument relied on in the text respecting the changes which the body undergoes; but it appears from the rest of the passage that he had another topic or illustration in view—αλλα γαρ αν φαιην ἑκαστην των ψυχων πολλα σωματα κατατριβειν, αλλως τε κἀν πολλα ετη βιῳ. Ει γαρ ῥεοι το σωμα και απολλυοιτο, ετι ζωντος του ανθρωπου, αλλ' ἡ ψυχη αει το κατατριβομενον ανυφαινοι, αναγκαιον μεντ' αν ειη, ὁποτε απολλυοιτο ἡ ψυχη, το τελευταιον ὑφασμα τυχειν αυτην εχουσαν, και τουτου μονου προτεραν απολλυσθαι—"*But I should rather say that each of our souls wears out many bodies, though these should live many years; for if the body runs out and is destroyed, the man still living, but the soul always repairs that which is worn out, it would follow of necessity that the soul when it perished would happen to have its last covering, and to perish only just before that covering.*"—'Phæd.' A singular instance of the incapacity of the ancients to observe facts, or at least the habitual carelessness with which they admitted relations of them, is afforded in another of these arguments. Socrates is made to refer, in the 'Phædo,' to the appearance of ghosts near places of burial as a well-known and admitted fact, and as proving that a portion of the soul for a while survived the body, but partook of its nature and likeness, and was not altogether immortal. This distinction between the mortal or sensitive and the immortal or intellectual part of the soul pervades the Platonic theism. We have observed already in the statement of Plutarch, that the Platonists held the νους or intellect to be contained in the ψυχη or soul, and the same doctrine occurs in other passages. Aristotle regards the soul in like manner as composed of two parts—the active, or νους, and the passive: the former he represents as alone immortal and eternal; the latter as destructible, τουτο μονον αθανατον και αΐδιον, ὁ δε παθητικος φθαρτος.—'Nic. Eth.'

It must, however, be admitted, that the belief of the ancients was more firm and more sound than their reasonings were cogent. The whole tenor of the doctrine in the 'Phædo' refers to a renewal or continuation of the soul as a separate and individual existence, after the dissolution of the body, and with a complete consciousness of personal identity—in short, to a continuance of the same rational being's existence after death. The liberation from the body is treated as the beginning of a new and more perfect life—τοτε γαρ αυτη καθ' αὑτην ἡ ψυχη εσται χωρις του σωματος· προτερον δ' ου (τελευτησασι). Xenophon thus makes Cyrus deliver himself to his children on his death-bed—Ουτοι εγωγε, ω παιδες, ουδε τουτο πωποτε επεισθην ὡς ἡ ψυχη, ἑως μεν αν εν θνητῳ σωματι ῃ, ζῃν, ὁταν δε τουτου απαλλαγῃ, τεθνηκεν—ουδε γε ὁπως αφρων εσται ἡ ψυχη, επειδαν του αφρονος σωματος διχα γενηται, ουδε τουτο πεπεισμαι· αλλ' ὁταν ακρατος και καθαρος ὁ νους εκκριθῃ, τοτε και φρονιμωτατον εικος αυτον ειναι.* Cicero has translated the whole passage upon this subject beautifully, though somewhat paraphrastically; but this portion he has given more literally —"Mihi quidem nunquam persuaderi potuit, animos dum in corporibus essent mortalibus, vivere; quum exissent ex iis, emori: nec vero tum animum esse insipientem, quum ex insipienti corpore evasisset; sed quum omni admixtione corporis liberatus purus et integer esse cœpisset, eum esse sapientem."†—"For I, my sons, never could persuade myself that the soul was living while it continued in a mortal body, and died when dismissed from it; nor could I ever persuade myself that it became unintellectual on its separation from an unintellectual body; but that when the mind acted without restraint and was purified (was freed from admixture with the body), then it became most intellectual."

None of the ancients, indeed, has expressed himself more clearly or more beautifully upon the subject than this great philosopher and rhetorician. His reasoning, too, respecting it, greatly exceeds in soundness and in sagacity that of the Grecian sages. Witness the admirable argument in the Tusculan Questions. They who deny the doctrine, says he, can only allege as the ground of their disbelief the difficulty of comprehending the state of the soul severed from the body, as if they could comprehend its state in the body. "Quasi vero intelligant, qualis sit in ipso corpore, quæ conformatio, quæ magnitudo, qui locus."—"As if they could comprehend what it was even when in the body, its form, size, and situation." "Hæc reputent isti (he adds) qui negant animum sine corpore se intelligere posse; videbunt quem in ipso corpore intelligant. Mihi quidem naturam animi intuenti, multo difficilior occurrit cogitatio, multoque obscurior, qualis animus in corpore sit, tanquam alienæ domi, quam qualis, cum exierit, et in liberum cœlum quasi domum suam venerit."‡—"Such

* Cyrop. ii.
† De Senect. 80.—Here the words "omni admixtione," &c. are added.
‡ Tusc. Quæst. i. 22.

are the opinions of those who say that they cannot comprehend how the mind can exist distinct from the body, who yet comprehended it when it was in the body. To me, when I contemplate the nature of the soul, the subject is more obscure, and it is much more difficult to conceive what the soul is in the body, as in a house not belonging to it, than what it may be when it has left the body, and has come into the open heaven as into its own house." That he derived the most refined gratification from such contemplations, many passages of his writings attest; none more than those towards the close of the 'Cato Major,' which must often have cheered the honest labourers for their country and their kind in the midst of an ungrateful and unworthy generation. "An censes (ut de me ipso aliquid more senum glorier) me tantos labores diurnos nocturnosque, domi militiæque suscepturum fuisse, si iisdem finibus gloriam meam, quibus vitam essem terminaturus? Nonne melius multo fuisset otiosam ætatem et quietam sine ullo labore aut contentione traducere"—"Think you—to speak somewhat of myself after the manner of old men—think you that I should ever have undergone such toils, by day and by night, at home and abroad, had I believed that the term of my life was to be the period of my renown? How much better would it have been to wile away a listless being and a tranquil, void of all strife, and free from any labour?"* And, again, that famous passage: "O præclarum diem quum ad illud divinum animorum concilium cœtumque proficiscar; quumque ex hac turba et colluvione discedam!"—"Delightful hour! when I shall journey towards that divine assemblage of spirits, and depart from this crowd of polluted things!"†

The Platonic ideas of a future state, as well as those adopted by the Roman sage, distinctly referred to an account rendered, and rewards or punishments awarded for the things done in the body—χρη παντα ποιειν, says Plato, ὥστε αρετης και φρονησεως εν τῳ βιῳ μεταςχειν· καλον γαρ ταθλον και ἡ ελπις μεγαλη—"*We ought to act in all things so as to pursue virtue and wisdom in this life, for the labour is excellent and the hope great.*"—('De Legg.' x.) Τον δε οντα ἡμων ἑκαστον οντως αθανατον ειναι, ψυχην επονομαζομενον, παρα θεοις αλλοις απιεναι, δωσοντα λογον, καθαπερ ὁ νομος ὁ πατρῳος λεγει, τῷ μεν αγαθῷ θαῤῥαλεον, τῷ δε κακῷ μαλα φοβερον—"*In truth each of us—that is to say each soul—is immortal, and departs to other Gods* (or *Gods in another world*) *to render an account as the laws of the state declare. This to the good is matter of confidence, but to the wicked of terror.*"—('De Legg.' xii.) So in the beginning of the 'Epinomis,' he says that a glorious prospect (καλη ελπις) is held out to us of attaining, when we die, the happiness not to be enjoyed on earth, and to gain which after death we had exerted all our efforts. In the 'Phædo,' where he is giving a somewhat fanciful picture of the next world, he tells us that souls which have committed lesser crimes come εις την λιμνην και εκει οικουσι τε και καθαιρομενοι των δε αδικηματων διδοντες δικας απολυονται ει τις τι ηδικησε—"*they remain in that space, and being cleansed* (or *purged*) *of their offences, are released;*" (from whence the idea and the name of *purgatory* has been taken). But such as have been incurably wicked, murderers and others, are driven, he says, into Tartarus, ὅθεν ουποτε

* De Senect. 82. † Ibid. 85.

εκβαινουσιν, "*whence they never more escape.*"* It is remarkable, that in the same work, Plato, if some words have not been interpolated in the text, looks forward to some direct divine communications of light upon this subject; but recommends abiding by the light of reason till that shall be granted. Let us, he says, choose the best human reason, and, sitting on it like a raft, pass through the dangers of life, unless (or until) ει μητις δυναιτο ασφαλεστερον και ακινδυνοτερον επι βεβαιοτερου οχηματος η λογου θειου τινος διαπορευθηναι—"*unless some one can pass us over more easily and safely upon some stronger vehicle or divine word.*"†

The passage in the 'Somnium Scipionis,' where celestial enjoyments are held out as the rewards of public virtue, is well known. The precision indeed of the language touching a future state, which marks this treatise, is singular, approaching to that of the New Testament—"beati ævo sempiterno fruuntur"—"the blessed enjoy eternal life;"—"ea vita via est in cœlum et in hunc cœtum eorum qui jam vixerunt et corpore laxati illum incolunt locum"—"this life is the road to heaven and to the society of those who, liberated from the body, inhabit that place;"—"immo vero ii vivunt, qui ex corporum vinculis, tanquam e carcere, evolaverunt; vestra vero, quæ dicitur vita, mors est"—"they live indeed who, freed from the chains of the body, have flown away as from a prison; but your life, as it is called, is death;"—"sic habeto, non esse te mortalem, sed corpus hoc; nec enim tu is es, quem forma ista declarat, sed mens cujusque, is est quisque"—"consider thus, that thou art not mortal, but thy body only; for thou art not that which thy form exhibits, but the mind of every man is the man;"—"animus in domum suam pervolabit, idque ocius faciet, si jam tum, quum erit inclusus in corpore, eminebit foras, et ea quæ extra erunt contemplans, quam maxime se à corpore abstrahet"—"the soul will fly away to its home, and that the more readily, if, while included in the body, it elevates itself above the body by the contemplation of those things which especially abstract it from the body." These things have given rise to doubts of the authenticity of the treatise—doubts easily removed by looking to the many absurdities respecting the celestial bodies and the other accompaniments of heaven with which the work abounds; to the Platonic doctrine respecting motion as the essence of mind, which it adopts; and also to the doctrine distinctly stated of the pre-existent state.

Note IX.—Page 85.

Of Bishop Warburton's Theory concerning the ancient Doctrine of a Future State.

To any one who had read the extracts in the last Note, but still more to one who was familiar with the ancient writers from whose works they are taken, it might appear quite impossible that a question should ever be raised upon the general belief of antiquity in a Future State, and the belief of some of the most eminent of the philosophers, at least, in a state of

* Phæd. † Ibid.

rewards and punishments. Nevertheless as there is nothing so plain to which the influence of a preconceived opinion and the desire of furthering a favourite hypothesis will not blind men, and as their blindness in such cases bears even a proportion to their learning and ingenuity, it has thus fared with the point in question, and Bishop Warburton has denied that any of the ancients except Socrates really believed in a future state of the soul individually, and subject to reward or punishment. He took up this argument because it seemed to strengthen his extraordinary reasoning upon the Legation of Moses. It is therefore necessary first to state how his doctrine bears upon that reasoning.

His reasoning is this. The inculcating of a future state of retribution is necessary to the well-being of society. All men, and especially all the wisest nations of antiquity, have agreed in holding such a doctrine necessary to be inculcated. But there is nothing of the kind to be found in the Mosaic dispensation. And here he pauses to observe that these propositions seem too clear to require any proof. Nevertheless his whole work is consumed in proving them; and the conclusion from the whole, that therefore the Mosaic law is of Divine original, is left for a further work, which never appeared; and yet this is the very position which all, or almost all who may read the book, and even yield their assent to it, are the most inclined to reject. Indeed it may well be doubted if this work, learned and acute as it is, and showing the author to be both well read and well fitted for controversy, ever satisfied any one except perhaps Bishop Hurd, or ever can demonstrate anything so well as it proves the preposterous and perverted ingenuity of an able and industrious man.

That such was very far from being the author's opinion we have ample proof. He terms his work 'A Demonstration.' He describes his reasoning "as very little short of mathematical certainty," and "to which nothing but a mere physical possibility of the contrary can be opposed;" and he declares his only difficulty to be in "telling whether the pleasure of the discovery or the wonder that it is now to make be the greater." Accordingly in the correspondence between him and his friend Bishop Hurd, the complete success of the 'Demonstration' is always assumed, and the glory of it is made the topic of endless and even mutual gratulation, not without pity and even vituperation of all who can remain dissatisfied, and who are habitually and complacently classed by name with the subjects of Pope's well-known satire.

The two things which the author always overlooked were the possibility of a human lawgiver making an imperfect system, and of sceptics holding the want of the sanction in question to be no argument for the divine origin of the Mosaic law, but rather a proof of its flowing from a human and fallible source. As these "mere possibilities" are wholly independent of the admission that every word in the book is correct, and all the positions are demonstrated, and as nothing whatever is said to exclude such suppositions, it is manifest that a more useless and absurd argument never was maintained upon any grave and important subject. The merit of the book lies in its learning and its collateral argument; indeed nearly the whole is collateral, and unconnected with the purpose of the reasoning. But much even of that collateral matter is fanciful and unsound. The fancy that the descent of Æneas to hell in the sixth book of the 'Æneid' is a veiled account of the Eleusinian Mysteries, has probably made as few proselytes as the main body of the 'Demonstration;' and if any one has lent his ear to the theory that the ancients had no belief in a future state of retribution, it can only be from being led away by confident assertion from the examination of the facts.

This position of Bishop Warburton is manifestly wholly unnecessary to the proof of his general theory. But he thought it would show more strongly the opinion entertained of the uses to be derived from inculcating the doctrine of a Future State, if he could prove that they who held it in public, and with political views, did not themselves believe it.

The way in which he tries to prove this is by observing that there prevailed among the old philosophers, as well as lawgivers, a principle of propagating what they knew to be false opinions for the public benefit, and of thus holding one kind of doctrine in secret, the *esoteric*, and another, the *exoteric*, in public. Of this fact there is no doubt, but its origin is hardly to be thus traced to design always prevailing. The most ancient notions of religion were the birth of fear and ignorance in the earliest ages, and the fancy of the poets mingled with these, multiplying and improving and polishing the rude imaginations of popular terror and simplicity. The rulers of the community, aiding themselves by the sanctions which they drew from thence, favoured the continuance and propagation of the delusions: and philosophers who afterwards arose among the people were neither disposed themselves nor permitted by the magistrate openly to expose the errors of the popular faith. Hence they taught one doctrine in private, while in public they conformed to the prevailing creed, and the observances which it enjoined.

But whatever be the origin of the double doctrine, Bishop Warburton cannot expect that its mere existence, and the use made of it by ancient writers and teachers will prove his position, unless he can show that the future state of retribution is only mentioned by them upon occasions of an *exoterical* kind, and never when *esoterically* occupied. Now this he most signally fails to do; indeed he can hardly be said fairly to make the attempt, for his rule is to make the tenor of the doctrine the criterion of *esoteric* or *exoteric*, instead of showing the occasion to be one or the other from extrinsic circumstances, which is manifestly begging the question most unscrupulously. It seems hardly credible that so acute and practised a controversialist should so conduct an argument, but it is quite true. As often as anything occurs in favour of a Future State, he says it was said *exoterically;* and whenever he can find anything on the opposite side, or leaning towards it (which is really hardly at all in the Platonic or Ciceronian writings), he sets this down for the *esoteric* sentiments of the writer. But surely if there be any meaning at all in the double doctrine, whatever may have been its origin, the occasion is everything, and there can be no difficulty in telling whether any given opinion was maintained *esoterically* or not, by the circumstances in which, and the purposes for which, it was propounded.

The argument on which he dwells most is drawn from the allusion made by Cæsar in the discussion upon the punishment of the conspirators as related by Sallust, "Ultra (mortem) neque curæ neque gaudio locum esse;" and from the way in which Cato and Cicero evade, he says, rather than answer him, appealing to the traditions of antiquity and the authority of their ancestors instead of arguing the point. ('Div. Leg.' III. 2. 5.)

Can anything be more inconclusive than this? Granting that Sallust, in making speeches for Cæsar and Cato (whom by the way he makes speak in the self-same style, that is, in his own Sallustian style), adhered to the sentiments each delivered; and further, that Cæsar uses this strange topic not as a mere rhetorical figure, but as a serious reason against capital punishment, and as showing that there is mercy and not severity in such inflictions (a very strong supposition to make respecting so practised and so practical a reasoner as Caius Cæsar); surely so bold a position as practical atheism brought forward in the Roman senate was far more likely to be met, whether by the decorum of Cato or the skill of Cicero, with a general appeal to the prevalence of the contrary belief, and its resting on ancient tradition, than with a metaphysical or theological discourse singularly out of season in such a debate. To make the case our own: let us suppose some member of Parliament, or of the Chamber of Deputies, so ill judged as to denounce in short but plain terms the religion of the country, —would any person advert further to so extravagant a speech than to blame it, and in general expressions signify the indignation it had excited? Would not an answer out of Lardner, or Paley, or Pascal be deemed almost as ill-timed as the attack? To be sure neither Cato nor Cicero are represented as testifying any great disgust at the language of Cæsar, but this, as well indeed as the topic being introduced at all by the latter, only shows that the doctrine of a Future State was not one of the tenets much diffused among the people, or held peculiarly sacred by them. Had the orator vindicated Catiline by showing how much less flagitious his bad life was than that of some of the gods to whom altars were erected and worship rendered, a very different burst of invective would have been called down upon the blasphemous offender.

In truth, the passage thus relied upon only shows, like all the rest of the facts, that the doctrine of retribution was rather more *esoteric* than *exoteric* among the ancients. The elaborate dissertation of Bishop Warburton's upon the Mysteries, proves this effectually, and clearly refutes his whole argument. For to prove that the doctrine of future retribution was used at all as an engine of state, he is forced to allege that it was the secret disclosed to the initiated in the Sacred Mysteries; which, according to Cicero, were not to be viewed by the imprudent eye. (Ne imprudentiam quidem oculorum adjici fas est, 'De Legg.' II. 14). Surely this would rather indicate that such doctrines were not inculcated indiscriminately, and that at all events, when a philosopher gives them a place in his works, it cannot be in pursuance of a plan for deceiving the multitude into a belief different from his own. It is indeed plain enough that the bulk of the people were restrained, if by any sanctions higher than those of the penal laws, rather by the belief of constant interposition from the gods. An expectation of help from their favour or of punishment from their anger in this life and without any delay, formed the creed of the Greeks and the Romans; and nothing else is to be found in either the preamble to Zaleucus the Locrian's laws quoted by Bishop Warburton, or in the passages of Cicero's treatise, to which he also refers. 'Div. Leg.' II. 3.

Among the many notable inadvertencies of his argument, concealed from himself by an exuberant learning and a dogmatism hardly to be paralleled, is the neglecting to observe how difficultly the appearance of the doctrine in the places where we find it is reconciled with his notion of its having formed the subject of the Mysteries. What part in those Mysteries did Cicero's and Plato's and Seneca's and Xenophon's writings bear? There we have the doctrine plainly stated; possibly to the world at large—possibly, far more probably, to the learned reader only—but assuredly not by the Hierophant or the Mystagogue, to the initiated. This is wholly inconsistent with the notion of its being reserved for these alone. It is equally inconsistent with the theory that it was promulgated for the purposes of deception; for such purposes would have been far better served by decidedly making it a part neither of the instruction given to the select and initiated few, nor of the doctrine confined to the students of philosophy, but of the common, vulgar, popular belief and ritual, which it is admitted not to have been. The truth undeniably is, that as, on the one hand, it was not universally preached and inculcated, so neither was it any mystery forbidden to be divulged—that it was no part of the vulgar creed, nor yet so repugnant to the religion of the country as to be concealed from prudential considerations, like the unity of the Deity, the fabulousness of the ordinary polytheistic superstitions, as to the gods and goddesses, the demigods, and the Furies. These opinions were indeed *esoteric*, and only promulgated among the learned. A few allusions, and but a few, are found to them in any of the classical authors whose writings were intended for general perusal, and chiefly to the parts which had in process of time become too gross even for the vulgar, such as the Furies, Cerberus, &c., which Cicero describes as unfit for the belief of even an ignorant or doting old woman (Quæ anus tam excors, &c. 'De Nat. Deor.,' and 'Tusc. Quæst.'), and which are treated as fables both by Demosthenes in that noble passage where he exclaims that the Furies, who are represented in the scene as driving men with burning torches (*ἐλαύνειν δᾳσὶν ἡμμέναις*), are our bad passions, and by Cicero in words (Hi faces, hæ flammæ, &c.) almost translated from the Greek.

After all, can anything be more violent than the supposition that those philosophers, for the purpose of deceiving the multitude, delivered opinions not held by themselves, and delivered them in profound philosophical treatises? It is in the 'Phædo' and the 'Timæus' (hardly intelligible to the learned), and the 'Tusculan Questions,' and the 'Somnium Scipionis,' in an age when there were hardly any readers beyond the disciples of the several sects, that those *exoteric* matters are supposed to be conveyed for accomplishing the purposes of popular delusion—not in poems and speeches, read in the Portico or pronounced in the Forum. If then the records of their opinions on the most recondite subjects were chosen for the depositories of *exoteric* faith, where are we to look for their *esoteric* doctrines? Bishop Warburton must needs answer, in the very same records; for to this he is driven, because he has none other; and he cannot choose but admit that the whole argument is utterly defective, if it stops short at only showing those opinions to have been delivered, even if proved to be *exoterical*, unless he can also show opposite doctrines to have been *esoterically* entertained—inasmuch as a person might grant the former to have been delivered for popular use (which, however, Bishop Warburton does not prove), and yet deny that they were assumed for the purpose of deception. Accordingly he is driven to find, if he can, proofs of those opposite doctrines in the self-same writings where he says the exoteric ones are conveyed. However, nothing surely can be more absurd than this; for it is to maintain that Plato and Cicero pretended to believe a future state of retribution in order to deceive the multitude, by stating it in the same writings in which they betrayed their real sentiments to be the very reverse. And this absurdity is the same, and this argument is as cogent, if we take the double doctrine to apply, not—as we are, in favour of the Bishop's argument, generally supposing—to a difference between what was taught in the face of the people and what was reserved for the scholars, but to a division of the scholars into two classes, one only of whom was supposed to see the whole truth—for the same writings on this subject are said to contain both the statements of it. Nevertheless let us shortly see how he finds any such contrary statements, or any means of explaining away the positive and precise dicta, and even reasonings, cited in the former note (Note VIII.).

1. There can be no doubt that both the Greek and Roman philosophers disbelieved part of the popular doctrine as to future retribution, those punishments to wit, which are of a gross and corporeal nature; and, accordingly, what Timæus the Locrian and others have said of the τιμωριαι ξιναι proves nothing, for it applies to those only. Strabo plainly speaks of these only in the passage where he observes that women and the vulgar are not to be kept pious and virtuous by the lessons of philosophy, but by superstition, which cannot be maintained without mythology (fable-making) and prodigies (δια δεισιδαιμονιας· τουτο δ' ουκ ανευ μυθοποιΐας και τερατειας), for he gives as examples of these, Jupiter's Thunder, the Snakes of the Furies, &c.

2. Nothing can be more vague than the inference drawn from such passages as those in Cicero and Seneca, where a doubt is expressed on the subject of a Future State, and a wish of more cogent proofs seems betrayed —as where Cicero makes one of his prolocutors, in the Tusculan Questions, say, that when he lays down the 'Phædo,' which had persuaded him, "assensio omnis illa elabitur" (i. 11),—"All that conviction glides away," and when Seneca speaks of the philosophers as "rem gratissimam promittentes magis quàm probentes,"—"Promising a pleasing thing rather than proving it," and calls it "bellum somnium."—('Epist.' 102.)—"A beautiful dream.'' No one pretends that the ancients had a firm and abiding opinion, founded on very cogent reasons, respecting a Future State; and with far sounder theologians than they were, the anxiety naturally incident to so momentous an inquiry may well excite occasional doubts, and even apprehensions. Who questions Dr. Johnson's general belief in Revelation, because in moments of depression, when desiderating some stronger evidence, he was kindly told by a religious friend that he surely had enough, and answered, "*Sir, I would have more?*"

3. When Strabo speaks of the Brahmins having invented fables, like Plato, upon future judgment, it is plain that he alludes to those speculations in the 'Phædo,' which are avowedly and purposely given as imaginary respecting the details of another world. To no other part of the Platonic doctrine can the Brahminical mythology be likened: nor would there be any accuracy of speech at all in comparing those fables to the more abstract doctrines of the immortality of the soul, as the words literally do—(ὡσπερ και Πλατων περι της αφθαρσιας ψυχης).

4. The quotation from Aristotle may refer to this world merely, but it is certainly made a good deal stronger in Bishop Warburton's translation

—*φοβερωτατον δε θανατος· περας γαρ, και ουδεν ετι τῷ τεθνεωτι δ' ουκ ει, ουτε αγαθον, ουτε κακον ειναι.* "Death (as our author renders it) is of all things the most terrible; for it is the final period of existence, and beyond that, it appears there is neither good nor evil for the dead man to dread or hope." This is, at the best, a mere paraphrase. Aristotle says—"*Death is most terrible, for it is an end (of us), and there appears to be nothing further, good or bad, for the dead.*" Even were we to take this as an avowal of the Stagyrite's opinion in the sense given it by Bishop Warburton, it proves nothing as to Plato.

4. Some of the Stoics seem certainly to have held that the dissolution of the body closed the scene, and that the body ceased to exist by the resolving of its mortal frame into the kindred elements. Nevertheless, many of their observations may be conceived to regard the vulgar superstitions, and many of their sayings to flow from the habit of grandiloquent contempt for all bodily suffering. However, no one maintains that all the ancient sects of Theists, and each disciple of every sect, firmly believed in a future state; and it must be remarked that the question raised by Bishop Warburton being as to the belief in a state of retribution, his citations from Seneca and Epictetus go to deny the future continuance of the soul altogether. Now he does not deny that at least some of the ancients did believe in this.

5. But the authority of Cicero presses our author the most closely, and accordingly he makes great efforts to escape from it. After showing some circumstances, rather of expression than anything else, in his philosophical treatises, he cites the oration 'Pro Cluentio,' where, speaking of the vulgar superstition, he says it is generally disbelieved; and then asks, "Quid aliud mors eripuit præter sensum doloris?"—"What has death taken away besides the sense of pain?" But this at best is a rhetorical flourish; and being delivered in public (though before the judges), never could be seriously meant as an *esoteric* attack on the doctrine. The doctrines in the 'De Officiis' relate only to the Deity's being incapable of anger or malevolence, on which account he praises Regulus the more for keeping his oath when all philosophers knew *nec irasci Deum nec nocere;* which shows, according to our author, that Cicero could not believe in future retribution. But this is said by Cicero only in reference to immediate punishments, or judgments, as the vulgar term them. At any rate, the passage is quite capable of this sense, and every rule of sound construction binds us to prefer it as consistent with the other passages on a future state, while those passages will bear no meaning but one. We may here observe, in passing, the gratuitous manner in which works are held *esoteric* and *exoteric*, just as suits the purposes of the argument. The 'Offices' contain the above passage, and therefore, Bishop Warburton says it is the work which "bids the fairest of any to be spoken from the heart." The passage in the 'Somnium Scipionis,' "Omnibus qui patriam conservarint, adjuverint, auxerint, certum esse in cœlo, ad definitum locum ubi beati ævo sempiterno fruantur," ('Som. Scip.' 37)—"All who protect, assist, and extend their country, are sure to go to heaven, to the appointed spot where they are to enjoy eternal blessedness," is got rid of, by saying that the ancients believed souls to be either human, or heroic and demonic, and that the two last went to heaven to enjoy eternal happiness, but that the former, comprehending the bulk of mankind, did not. This is begging

the question to no purpose, for it is also giving up the point, and at the utmost only reduces the author's position to a denial that the ancients believed in the immortality of *all* souls. It must, however, be observed, that unless he is allowed to assume also something like election and predestination, he gains hardly even this in his argument; for if a man by patriotic conduct can become one of the heroic souls, and so gain eternal life, what more distinct admission can be desired of a future state of retribution? That the doctrine of immortality was, by many at least, confined in some such way, may be true. That beautiful passage in Tacitus seems to point that way, "Si non cum corpore extinguuntur *magnæ* animæ."—('Vit. Ag. sub fin.')—"If great souls are not annihilated with the body." The main proof, however, against Cicero's belief is drawn from the Epistles, where alone, says our author, we can be sure of his speaking his real sentiments. Yet never did proof more completely fail. Writing to Torquatus, he says, "Nec enim dum ero, angar ullâ re, cum omni vacem culpâ—et si non ero, sensû omnino carebo," (Lib. vi. Ep. 3.); —"For, if I exist, I shall feel no anguish from anything, being free from all guilt; and if I do not exist, I shall be devoid of all sensation;" and to Toranius, "Ima ratio videtur, ferre moderate, præsertim cum omnium rerum mors sit extremum," (Lib. vi. Ep. 21.)—"The deepest reason seems to be, to endure patiently, especially as death is the end of all things." And this, which really means nothing more than a common remark on death ending all our pains and troubles, the learned author calls "professing his disbelief in a future state of retribution in the frankest manner."—'Div. Leg.' iii. 3.

It seems, therefore, not too much to say that the 'Divine Legation' does not more completely fail in proving the grand paradox which forms the main object of the argument, and which has been parodied by Soame Jenyns, in his most injudicious defence of Christianity, than it does in supporting the minor paradox which is taken up incidentally as to the real opinions of the ancients, and which, it must be admitted, is indeed quite unnecessary to the general argument, and as little damages it by its entire failure, as it could help it by the most entire success.

Note X.—Section VI., p. 89.

A learned and valuable work upon the life of Lord Bacon has been published by Mr. B. Montagu. Some very important facts are proved satisfactorily by the ingenious author, and show how much the criminality of this great man is exaggerated in the common accounts of his fall. But it is clearly shown, that he was prevailed upon by the intrigues of James I. and his profligate minister to abandon his own defence, and sacrifice himself to their base and crooked policy—a statement which disgraces them more than it vindicates him. One thing, however, is undeniable—that they who so loudly blame Bacon overlook the meanness of almost all the great statesmen of those courtly times.

DIALOGUES ON INSTINCT.

Place—Brougham, in Westmoreland.
Time—September, 1837.
Persons—*A*. Lord Spencer (Althorp).
B. Lord Brougham.

OF INSTINCT.

BOOK, OR DIALOGUE I.

INSTINCT—Introduction; (Facts).

When the General Election of 1837 was near its close, and every day brought the accounts of those mighty boasts of our expected successes under the new reign, so idly made, being overthrown by the activity and resources of our adversaries and the listlessness of the people on our behalf, Lord A. came to me on his way to the North, where he was minded to diversify with field-sports his habitual life of farming. Those pursuits had never interfered with the duty he owed his country as long as he deemed that the sacrifice of all his domestic comforts could prove serviceable to his public principles; nor had they ever at any time prevented him from cultivating a sound philosophy, in the study of which much of his leisure is always consumed. When I passed a few days with him at Wiseton, the summer before, we had discussed together some of the more interesting topics which form the subject of these speculations, connected with Natural Theology, though of a substantive interest independent of the relation in which they stand to that sublime inquiry; and, while I remained at Harrington, we had corresponded constantly on the subject of Instinct, one of the most curious in its minute details and of the most interesting in its bearings upon the philosophy of mind, independent of its immediate connexion with theological speculations, but, it must at the same time be admitted, one of the most difficult, and upon which the labours of philosophers have cast a very imperfect light. It was natural then that we should renew these discussions when we afterwards met in Westmoreland. The weather being fine, we ranged somewhat among the lake scenery, and by the rivers and through the woods which variegate our northern country. There was not much to tempt us in the aspect of public affairs, which, if not gloomy for the country at large, was yet not very flattering for the liberal party, among whom the single object seemed now to be the retention of office, and who might say with the Roman patriot in the decline of liberty,—"Nostris enim vitiis, non casû aliquo, rempublicam verbo retinemus, reapse vero jampridem amisimus."* Nor, indeed, on these matters was there a perfect agreement between us two; for while we augured as little favourably the one as the other of our prospects, we ascribed to different causes the condition of affairs which gave rise to those forebodings: he, tracing it to the great natural weight and influence of the Tories throughout the country, both in church and state; I, relying more on the energies of an improved and active people, provided the government had acted so as to merit their support; but lamenting that no pains had been taken by them to show any superiority of popular principles, or make the country feel itself better off under their rule than they would have been under the adverse faction, while I perceived sufficiently plain indications that the accession of the Court favour in this new reign would have the effect of lessening rather than promoting any popular tendencies which might still exist. Altogether, therefore, the state of the commonwealth was a subject less suited to engage our conversation; and we naturally dwelt

* "By our own misconduct, not by any calamity, though we may still have the name of a free government, we yet have lost the reality."—*Cic. Frag. de Rep.* lib. v.

little upon passing and unpleasing topics, as unsatisfactory, transitory, and fleeting—"ista quæ nec percunctari nec audire sine molestiâ possumus." * But upon those matters of permanent interest and universal importance, and which the follies or faults of men could not despoil of their dignity or deprive of their relish, we loved to expatiate; and coming to the island in the neighbouring river, found a convenient seat where the discussion might be carried on under the cool shade which the wood afforded against an autumnal sun: "Here," said I, "we may resume our Wiseton conversation."—"Ventum in insulam est. Hâc vero nihil est amœnius; utenim hoc quasi rostro finditur Fibrenus, et divisus equaliter in duas partes latera hæc alluit, rapideque dilapsus cito in unum confluit, et tantum complectitur quod satis sit modicæ palæstræ lŏci; quo effecto tanquam id habuerit operis ac muneris ut hanc nobis efficeret sedem ad disputandum, statim præcipitat in Lirem." †—"Here," said I, "we may resume our Wiseton conversation:" "si videtur considamus hic in umbrâ, atque ad eam partem sermonis ex quâ egressi sumus revertamur." ‡

A. Have you reconsidered my opinion, or rather the inclination of opinion, which I had last year, that it will be advisable, if not necessary, to begin with defining Instinct, in order that we may the more clearly understand what we are discussing?

B. I have indeed; and I remain of my own, as often

* "Things which we can neither inquire about nor hear without vexation."—*Cic. Acad. Quæst.* lib. ii.

† "We came to the island. But than this spot nothing can be more agreeable; for here the Fibrenus is split as by the prow of a vessel, and being divided into two equal branches, washes the sides; then, after rapidly separating, it quickly unites in one stream, embracing space enough of ground for a moderate-sized place of exercise: after which, as if it only had the work and office of providing us with a seat for our discussion, it straightway falls into the Liris."—*Cic. de Leg.* lib. ii.

‡ "If you please we may here sit down under this shade, and revert to that part of our conversation from which we had departed."—*Cic. de Leg.* lib. ii.

happens through obstinacy and unwillingness to give up a preconceived notion; but here it is, I believe, from much reflection upon the subject, that I still regard the definition as rather the end of our inquiry than its commencement. Indeed, this may generally be observed of metaphysical, or rather psychological inquiries: they are not like those of the mathematician, who must begin by defining; but that is because his definition is, in fact, a statement of part of the hypothesis in each proposition. Thus, whoever enunciates any proposition respecting a property of the circle, predicates that property of a figure whose radii are all equal; and it is as if he began by saying, "Let there be a curve line, such that all the straight lines drawn from its points to another point within it are equal, then I say that the rectangles are equal, which, &c." The general definition only saves the trouble of repeating this assumption, as part of the hypothesis in each proposition. But the nature of instinct, or of any other thing of which we discourse in psychology, is not the hypothesis we start from; it is the goal or conclusion we are seeking to arrive at. Indeed, so it is in physical science also; we do not begin, but end, by defining the qualities of bodies, or their action on one another.

A. I grant this. But if there be more things than one which men call by the same name, for example, of Instinct, must we not begin by ascertaining what we mean by the word, in order to avoid confusion? And this seems to bring on the necessity at least of some definition.

B. I agree that there must in this case be a definition; but it is only a definition of terms, and does not imply our stating the nature of the thing defined: it only implies that we must understand what the thing is to which the given word applies, and, if two things go under the same name, that we should be agreed in the outset which of the two things we mean when we use the word; perhaps, that we invest some second name, or give some qualifying addition to the given one, to express one of the two things, and keep the different meanings distinct.

A. The best way will be that we should come to particulars—give an example or two: perhaps it may suffice to mention the different kinds of Instinct, if, which I take for granted you do not doubt, there be more things than one going under that name.

B. Certainly; and there can here be no difficulty at all in our way; and, to show you how little alarmed I am at defining, when it is clear that I am only called upon to define a word, and thereby make a distinct reference to a thing known or unknown in its own nature—not to pretend giving an account of that nature—I will at once begin by both inventing names and defining their meaning. There are some Instincts which may be called *physical*, and others *mental*, in the animal system; by physical I mean those actions or motions or states of body which are involuntary; as the action of the heart, and the peristaltic motion of the bowels, over which, generally speaking, we have no direct control by the operation of the will—for I put out of view such rare instances, almost monstrous, as Darwin has recorded of a person who could suspend the pulsations of his heart at pleasure, and another, still more rare, of one who could, at will, move his bowels by accelerating the peristaltic action.* Even if all men could acquire such control over those motions, they would still be involuntary; because they could still be carried on wholly without our will interfering, and without our minds necessarily having any knowledge whatever of them. So the secretions are all performed involuntarily, and may go on wholly without our knowledge; we can affect them as we can the involuntary motions of the heart and fluids, indirectly, because the passions and feelings of the mind have

* Zoonomia.

always an effect upon them; but still they exist and proceed, the parts perform their functions, and those functions serve the ends of their appointment, wholly independent of our will, or of any effort whatever on our part. We can affect them also immediately through the influence of physical agents, voluntarily applied as stimulants or sedatives, or the operation of voluntary motion, as well as mediately by the power which the mind derives from its union with the body; but they can go on of themselves, and, in all cases of healthy condition, go on better without any the least interruption on our part than with it.

A. This is certain: my only doubt is whether these can be justly or correctly termed instinctive operations at all. When I speak of Instinct, I mean something very different; namely, those voluntary movements, or that voluntary action of the mental faculties which is contradistinguished from reason. However, there is no harm, but much convenience, in beginning by defining and classifying, so as to leave on one side the physical and involuntary instincts—those things which may properly enough be called incidents of animal life, because there seems great difficulty in drawing a line between such motions and actions and those which subsist in vegetables.

B. There does certainly appear to be this difficulty. I hardly see how any line can be drawn between the motions of the lowest species of animal, the mollusca for instance, and those found in plants. There is in both organized form, a system of vessels, growth by extension not by apposition, a circulation of fluids and secretion of solids from those fluids, or of one fluid from another. There is also production of seed, and from the seed continuation of the species. But it is not only convenient that we should define in order to leave on one side what we are not to discuss, that it may not confound our inquiry; the definition and classification may also carry us on, some little way, in our argument with respect to the other class of Instincts, Instinct properly so called, the Mental Instincts; at least, it seems to furnish us at the very outset with an analogy.

A. I have a dread, at least a suspicion, of all analogies, and never more than when on the slippery heights of an obscure subject; when we are as it were *inter apices* of a metaphysical argument, and feeling, perhaps groping, our way in the dark or among the clouds. I then regard analogy as a dangerous light, a treacherous *ignis fatuus*.

B. It is even so, if we follow it beyond where we can see quite clear and find a firm footing. But all light is good, and the best way is not to despair, still less put out any glimmering we have, but rather to increase it by adding others, or make it available by using apt instruments. However, we are getting too metaphorical: only it is my comfort that you began, and that I am led astray by one who (as you said in your inimitable letter to your Lancashire antagonist) is not one of "the eloquent people." But to return from where your poetical imagery led us—analogy may sometimes illustrate, and it may often lead to useful and strict inquiry, by suggesting matters for comparison and investigation.

A. Then what comparison do you make between the two kinds of Instinct? or rather, as the question is of analogy, how do you state a relation of the mental Instinct, which we shall call Instinct simply if you please, similar to or identical with some relation of physical Instinct?

B. As thus—the physical Instincts are independent of will, or mind altogether, though they never are found except where animal life and consequently mind exists; but yet mind may influence them. Just so the mental Instincts are independent of reason altogether, though they are found in union with it and reason may influence them. It is a question if they are ever found without reason; for that depends on our solution of the *vexata quæstio*, "Whether the lower animals have reason at all or no?" Therefore, I will not say that here the analogy is complete, and will not affirm that, as physical Instinct is never found without animal life, so mental Instinct is never found without reason; but we may safely say that in this other respect the analogy is perfect, namely, that where mental Instinct is found with reason it can act without reason, though reason may also interfere with it; and in this respect, at least, reason seems to bear the same relation to mental Instinct which animal life bears to physical Instinct. We may go farther, and add, that as in plants, where the motions are without animal life, those motions are more perfect and more undisturbed, so if there be any animal wholly without reason, the operations of mental Instinct are the more regular and perfect; and, in any animal whatever, they are so in proportion as reason is dormant or inactive.

A. It may be as you say; but this will not carry us, as you seem to be aware, far on our road. However, it is well enough to remark it; for we thus gain perhaps a clearer and more steady view of the relation between Reason and Instinct, always supposing that there is any warrant for treating the two as different: because you are aware that some have considered them as identical: I mean not merely by denying that there is any specific difference, any difference in kind, between our faculties and those of brutes—though this denial is of course involved in their doctrine—but by going a step farther, and holding that what we call our Reason, and are so proud of, is merely a bundle of Instincts, as some have termed it—a more acute and perfect degree of Instinct. Smellie, in his entertaining work on the Philosophy of Natural History, holds this opinion.—That is a book, by the way, much less esteemed than it deserves, even as a collection of facts and anecdotes; but I also think the honest printer (for such he was) had a good deal of the philosopher in him. I suppose, as the well-educated printers in the foreign university towns, and some of our own Oxford men, used to be critics and scholars, from the atmosphere of the place, so your Edinburgh printer, when well bred, is a metaphysician.

B. You are right as to Smellie at least, and I agree with you as to his book, though it is too long, and in parts loosely reasoned, as well as not over-accurate in his facts, according to what I have heard from naturalists. But he was a man of considerable merit; and lived a good deal in the literary and scientific circles of Edinburgh. I knew him, but slightly. He would have done much more had his habits been less convivial. But I rather fancy the somewhat pretending title of his book tended to make men disallow the merit which it unquestionably has.

A. But what do you hold of the dogma in question, and of which he is perhaps the most round asserter?

B. I entirely deny it; nor do I conceive that any part of the subject is more free from all doubt than this, unless indeed we come to the question of liberty and necessity, and resolve the whole into a mere dispute about terms.

A. Liberty and necessity! preserve us!—I am taken by surprise. Why I had no idea that we could ever have got among those heights and clouds already—"apart set on a hill retired," and reasoning on "free-will," like the gentry more acute than amiable, who held their metaphysical disputations there.

B. Don't be alarmed—but the subjects in one single point do certainly touch. What I mean is this: if you say that, when a man reasons, one idea suggests another, and that he must follow the train, and can no more avoid drawing his conclusion, when he compares two ideas, than a bird can avoid building its nest in a particular fashion, or a bee can help making hexagonal cells, then you seem doubtless to liken Reason with Instinct. But this is true only on the supposition that a man's mind is mechanical, and that his faculties are placed beyond his control. Now, suppose it to be admitted that I cannot avoid drawing a certain conclusion from premises in mathematical matters—as that the three angles of a figure are equal to two right angles, if that figure have those three angles only—I am under no such necessity in any question of moral or probable evidence; and on a question like that different minds will differ, or the same mind at different times. Again, I am under no necessity—even if I admit that I have no choice on moral evidence—I am under *no necessity* of exercising my volition in one given way, unless indeed you deny that I have ever any free-will at all. If so, and if you contend that, the same motives being presented to my volition in the same circumstances, I must needs choose the same course, you may also contend that, the same circumstances being presented to my judgment in the same frame of the feelings, I must needs draw the same conclusion; and this may seem to make out an identity of Reason with Instinct: but this is the dispute of liberty and necessity which every man's consciousness and hourly experience decides in favour of liberty, except in so far as it is a mere dispute about terms. But I really do think that, allowing the question to be disposed of either way, there is a specific difference between Reason and Instinct: for, even upon the principle of necessity, suppose the man and the bee to be equally under the entire control of the premises in reasoning, and the circumstances or motives in willing, whatever it is that each does, be it the necessary consequence of the circumstances or not, is different in the two cases. Suppose that if the bee reasoned she would be under the necessity of drawing the same conclusion, and that if she exercised an election, she could not avoid choosing one course, and that it is the same with the man—it still is not only not proved that the bee does reason or choose, while we know that the man does, but the contrary seems proved.

A. How so? Were I to maintain the contrary I should deny that we have any such proof. How do you prove the negative proposition, that the bee does not reason and will?

B. Observe, I do not say we have the proof of the negative as clearly as we have of the affirmative. But, beginning with laying aside those actions of animals which are either ambiguous or are referable properly to reason, and which, almost all philosophers allow, show a glimering of reason; and confining ourselves to what are purely instinctive, as the bee forming a hexagon without knowing what it is, or why she forms it; my proof of this not being reason, but something else, and something not only differing from reason in degree, but in kind, is from a comparison of the facts —an examination of the phenomena in each case—in a word, from induction. I perceive a certain thing done by this insect, without any instruction, which we could not do without much instruction. I see her working most accurately without any experience, in that which we could only be able to do by the expertness gathered from much experience. I see her doing certain things which are manifestly to produce an effect she can know nothing about, for example, making a cell and furnishing it with carpets and with liquid, fit to hold and to cherish safely a tender grub, she never having seen any grub, and knowing nothing of course about grubs, or that any grub is ever to come, or that any such use, perhaps any use at all, is ever to be made of the work she is about. Indeed, I see another insect, the solitary wasp, bring a given number of small grubs and deposit them in a hole which she has made, over her egg, just grubs enough to maintain the worm that egg will produce when hatched—and yet this wasp never saw an egg produce a worm—nor ever saw a worm—nay, is to be dead long before the worm can be in existence—and moreover she never has in any way tasted or used these grubs, or used the hole she made, except for the prospective benefit of the unknown worm she is never to see. In all these cases, then, the animal works positively without knowledge, and in the dark. She also works without designing anything, and yet she works to a certain defined and important purpose. Lastly, she works to a perfection in her way, and yet she works without any teaching or experience. Now, in all this she differs entirely from man, who only works well, perhaps at all, after being taught—who works with knowledge of what he is about—and who works, intending and meaning, and, in a word, designing to do what he accomplishes. To all which may be added, though it is rather perhaps the consequence of this difference than a separate and substantive head of diversity, the animal works always uniformly and alike, and all his kind work alike—whereas no two men work alike, nor any man always, nay any two times alike. Of all this I cannot indeed be quite certain as I am of what passes within my own mind, because it is barely possible that the insect may have some plan or notion in her head implanted as the intelligent faculties are: all I know is the extreme improbability of it being so; and that I see facts, as her necessary ignorance of the existence and nature of her worm, and her working without experience, and I know that if I did the same things I should be acting without having learnt mathematics, and should be planning in ignorance of unborn issue; and I therefore draw my inference accordingly as to her proceedings.

A. Come, come, Master B., I begin to surround you and drive you from your original position, maintained both now and last summer, about the impossibility of defining. Have you not as nearly as possible been furnishing a definition? At least, are not the materials of definition brought together which you deprecated, and would have us reserve to the last?

B. Patience, good man—patience! What is this to what you have gone through? Fancy yourself once more in the House of Commons, on the Treasury bench, listening to ——— ———

A. God forbid!

B. Or suppose yourself again in Downing Street, with Drummond announcing a succession of seven deputations or of seventeen suitors.

A. The bare possibility of it drives me wild. Why, to convert you to the most absurd doctrine I could fancy—to make you swallow all the Zoonomia whole, and believe that men derive their love of waving lines and admiration of finely-mould forms from the habit of the infant in handling his mother's bosom, or even to drive you into a belief that the world was made by chance—would be an easy task compared to the persuading any one suitor at any one of the offices that you had any difficulty in giving him all he asks, or convincing any one of those seven deputations that there exists in the world another body but itself.

B. Or to convince any one man, who ever asked any one job to be done for him, that he had any one motive in his mind but the public good, to which he was sacrificing his private interest. I remember M. [Melbourne] once drolly observing, when I said no man could tell how base men are till he came into office, "On the contrary, I never before had such an opinion of human virtue; for I now find that no man ever drops the least hint of any motive but disinterestedness and self-denial—and all idea of gain, or advantage, is the only thing that none seem ever to dream of." But now compose yourself to patience and discussion—take an extra pinch of snuff—walk about for five minutes, a distance of five yards and back, with your hands in your breeches' pockets, and then return to the question with the same calmness with which you would have listened to a man abusing you by the hour in parliament, or with which you looked an hour ago, in the Castle farm, at the beast you had bred, and which by your complacent aspect I saw you had sold pretty well.

A. But, indeed, I sometimes can't help fancying that it may be as well to take our observations upon Instinct from the operations and habits of such large animals as him you speak of—at least, not from insects; because it is possible that if we could see as accurately all the detail of the latter as we do of the former, much of the marvellous might disappear, and we might be as well able to account for their proceedings, which now seem to us so unintelligible, as we are to account for those of the greater animals, which are clumsy and cumbrous enough, and rather appear to proceed from an obscure glimmering of reason than from an inexplicable power guiding them unconsciously to work with the perfection which we ascribe to the bee. In a word, might not the cells be found to have as many imperfections, as great deviations from the true form, as any of the ox's operations have from perfect exactness, if either the bee were as large as the ox, or our senses as acute as the bee's? Has she not as great aberrations from the exact pattern in proportion to her own size and to the instruments, her feet and feelers, which she works with? I throw this out as a matter very fit to be settled in the outset, in order that our own reasoning may not proceed upon gratuitous assumption.

B. For the sake of ascertaining how far the working is as perfect as it appears, I admit the importance of your observation; but for nothing more. I deny that it affects the body of the argument at all; because that depends in no degree upon the perfection of the work. Thus the proceedings of the solitary wasp are just as good for my purpose as those of the bee. Nay, the instinctive operations of the greater animals furnish exactly the same materials for reasoning, though they may not be so striking. However, to the point of your comparison—you must keep in mind that we have applied the powers of the microscope to the operations of the bee. Now, without going to an instrument of the power of Torre's, which magnified the linear dimensions between 2000 and 3000 times, and consequently the surface above 6,000,000 of times, take the much more ordinary power of 400, which magnifies the surface 160,000-fold—nay, if you take a microscope of only a 90-times magnifying power, you will see the work of the bee in a straight line, exactly as you do that of a man with the naked eye. But, I need hardly add that, if you only saw it a quarter as well, or with a glass that magnified 20 times, it would be enough: for then you would examine it as you do the beaver's with your naked eye. But, further, all the difficulty you suggest proceeds upon a fallacy. The lines may not be exactly even which the bee forms; the surfaces may have inequalities to the bee's eye though to our sight they seem plane; and the angles, instead of being pointed, may be blunt or roundish: but the proportions are the same; the equality of the sides is maintained, and the angles are of the same size; that is, the inclination of the planes is just—in other words, all the inequalities don't affect the proportions of the parts; for they are common to each thing compared with another; the axis running through the inequalities (to speak more rigorously) is in the true direction, and the junction of the two axes forms the angle of 60 degrees as accurately as if there were no inequalities. Now, then, the bee places a plane in such a position, whatever be the roughness of its surface, that its inclination to another plane is the true one required.

A. I suppose it is so; but, at any rate, the solitary wasp carrying the grubs in proper number and placing them in the hole over the egg, or the bee placing her egg in the liquor at the bottom of the cell, and making that cell of the length to which the worm when hatched will grow—she having never seen either the worm or the chrysalis—is sufficient for our purpose.

B. Not to mention the operations of the worm itself in spinning the cocoon, and making it precisely the size required to line or carpet the cell when expanded and applied to it—nay, the motions of the chick in the egg, which always begins at the same place, and moves itself on in the same direction, chipping away till it effects its own liberation—all of which must be prior to experience, and without the possibility of teaching.

A. You desired me last summer to examine, with a view to the same point, the ducklings hatched under a hen, and then taking the water, without the possibility of her teaching. They have the form, web-feet, &c., which enables them to swim, and which a chicken has not. Their manner of getting into the water I cannot say I well ascertained; but it is certain enough that the hen's proper brood would not have got in, and probably she would have succeeded in preventing them, though she might not be able to keep the ducklings out.

B. However, a more decisive case occurred to me afterwards: that of chickens hatched in the Egyptian ovens. I have lately seen an intelligent Bey and his aide-de-camp, who gave me the whole process; and, as was to be expected, there is not the slightest difference between the conduct and motions, and habits generally, of these chickens, and of such as are hatched and brought up by hens. This fact, as well as the working of the chrysalis in spinning the cocoon, and of the chick in chipping with its bill-scale, renders it quite unnecessary to inquire whether or not the honey-bee or social wasp work by instruction from other bees or wasps. That, however, appears to be impossible, when we consider that as many as 30,000 young insects come from one nest, to teach whom there are not old ones anything like enough; and to teach whom in a few hours, or even days, to work as exactly as themselves seems wholly impossible. The observation of cases where such teaching is impossible, as in the chrysalis and unhatched chicken, at once removes all doubt, and precludes the possibility of supposing that the wasp's and the bee's architecture can be traditional, or handed down by teaching, from the first insects of the species that were created. Henceforward, therefore, we must assume as part of the fact that the cells of the bee are made without any instruction or any experience, and are as perfect at first as they ever are; which, by the way, explains another peculiarity of instinct—that it never improves in the progress of time. The bee, 6000 years ago, made its cells as accurately, and the wasp its paper as perfectly, as they now do.

A. Let us advert to one thing more, and, having settled it, the way may at least be said to be cleared for the argument, perhaps somewhat of progress even to be made in the inquiry. You have been speaking of Instincts in the plural; of course you do not mean to be taken literally, as admitting more kinds of mental Instinct than one.

B. Certainly not; any more than when speaking of the mental faculties I admit of more minds than one, or more parts than one of a single mind. This last form of speech has been so used, or rather abused, especially by the philosophers of the Scottish school, accurate and strict as they for the most part are, that they seem to treat the mind as divided into compartments, and to represent its faculties as so many members, like the parts of the body. But it is one thing or being perceiving, comparing, recollecting—not a being of parts, whereof perception is one, reasoning another, and recollection a third; so Instinct is one and indivisible, whatever we may hold it to be in its nature, or from whatever origin we may derive it. This thing, or being, is variously applied, and operates variously. There are not different Instincts, as of building, of collecting food for future worms, of emigrating to better climates—but one Instinct, which is variously employed or directed. I agree with you, however, that we have now done something more than merely clearing away the ground. We have taken a first step, or, if you will, laid a foundation. We have ascertained the peculiar or distinctive quality of Instinct, and that which distinguishes it from Reason. It acts without teaching, either from others, that is, instruction, or from the animal itself, that is, experience. This is generally given as the definition or description of Instinct. But we have added another peculiarity, which seems also a necessary part of the description—it acts without knowledge of consequences—it acts blindly, and accomplishes a purpose of which the animal is ignorant.

A. I pause here and doubt of this addition. I perfectly admit the fact that it produces an effect, manifestly the object of its operation, and yet without knowing it, consequently without intending it or designing it. But there seems reason to think that it always intends to produce some one effect, and does produce it—that it has some one purpose, and accomplishes it, and so designs something which it does. Thus animals are impelled by hunger to eat; their eating produces chyle, blood, and all that is secreted from the blood; yet they had no design to promote their own growth and preserve their own life. At least they ate long before they had any such design or any knowledge that such would be the consequence of gratifying hunger. So of continuing their species. May not the solitary wasp, for instance, have its organs and its senses so constructed as to receive an immediate gratification from collecting and burying grubs? If so, her knowledge extended to one, the first, event, and she had the design in view of producing this event; though wholly ignorant of any subsequent event. The desire of the first event, the fact of that event being a gratification to the insect, was the means taken by the Creator of the insect for making her do that which was to produce the important consequence, forming the real object in view, though concealed from the animal. Thus we may conceive that the insect is endowed with an appetite for carrying grubs, and that this is so adjusted in point of intensity as to be satiated when just so many grubs are transported as will feed the next season's worm, which is endowed with the desire to eat these grubs, rejected as food by the parent insect. So the wasp's senses may make the flavour, or the smell (for that seems all she enjoys), of a living caterpillar more grateful than of a dead one; and hence she takes those that will keep sweet till her own grub is hatched.

B. I do not deny the possibility of all this; although there seems something gratuitous in it, and we possibly never can know the truth by any observations or experiments. I shall presently show why I do not think it would entitle us to erase this ignorance of what you would call the second event, or the object of the secondary design, from our list of the characteristics of Instinct. But in the meantime I will mention what occurs to me on your objection in point of fact. The instant that a solitary wasp is hatched, or a bee can fly, away they go to the spot where the caterpillars or the wax-yielding substances are to be found. What guides them through the air to things they cannot descry or do not know the use of?

A. It costs me no more to suppose that there is some smell or other sensation to guide them—some odour, for example, which penetrates the air, and being grateful to them makes them desire to approach the odoriferous body. Thus the bee smells the nectary of flowers; she flies to them, she sips, and the wax is secreted in her stomach. I grant you that I have more difficulty with her operation in using it.

B. You clearly have; for what should be the special gratification of that? We are admitting that she has no kind of knowledge that the cell is to be used in hatching and rearing the brood, any more than that a hexagonal figure, with a certain inclination of its rhomboidal bottom, is to enable her and her associates to employ the space and the wax in the way of all others most economical of room and work and materials; and so as just to accommodate the size of the unknown and unseen worm, chrysalis, or young bee, and no more—and also to suit its form.

A. I think I could suppose also in this case that her desire of action—her love of motion—is gratified by the operation, and is satiated by continuing that motion to a certain extent, where she stops.

B. But allowing your right to make all these suppositions equally gratuitous, one after another, and to extend them as the argument proceeds, and to relieve the pressure as the fact pinches—see what it is that you must assume. The comb is constructed thus. Wax-making bees bring a small mass of this material and place it vertically to the plane from which the comb is to hang down. Then other bees begin to excavate, one on one side, another on the other, and they work with such perfect nicety, as never to penetrate through the thin layer of wax; also so equally that the plate is of equal thickness all throughout, its surfaces being parallel. You must, therefore, suppose some repugnance at once to a plate ever so little thicker, and to one ever so little thinner than the plate's given thickness. Indeed, this supposition, which some naturalists have made, is wholly unsatisfactory, and shows no accurate regard to the facts any more than their notion (a most crude one) that the hexagon cells arise from so many cylinders pressing on each other. The supposed instinct not to perforate wax, but to draw back when they come to a given thickness, is inconsistent with the fact; for the original plate they work on is uneven and of different thicknesses on both sides, and there is no bee in the world (at least no social bee) that ever made cylindrical cells. Huber has distinctly shown, from having observed them at their work, that they make them in quite another way; nor indeed, if they did, could any pressure ever produce hexagons, and far less rhomboidal plates. The wax-worker's bringing plates of a given thickness is also wholly incapable of accounting for the angles, that is, the inclination of the plates—for supposing the bee to make a groove (as she does), and suppose she has some means of bisecting its arc by two chords, this only, with the thickness of the cake, would determine the depth of the rhomboid, and that can be easily shown not to be the rhomboid actually made. She therefore makes angles wholly independent of the thickness, not to mention that were we to admit that the cake's thickness governs the whole, we do not solve the problem; the difficulty is only removed a step; for then how is that exact thickness obtained? But this will not do even to that extent; a great deal more is done by the bee, and a great deal more must be supposed to make it conceivable that she has any immediate or primary intention. She works so that the rhomboidal plate may have one particular diameter and no other, and always the same length, and that its four angles may be always the same, the opposite ones equal to each other, but each two of different quantity from the other two; and then she inclines the plates at given angles to one another. Why is there such a gratification to the bee in a straight line—in a straight line at right angles to a plane—in rhomboids—in rhomboids with certain angles—any more than in lines or planes inclining at other angles to one another? Why is the bee, after working for half a quarter of a line in one direction, to go on, and not take delight in a change of direction? If she goes on, why is she to be pleased with stopping at one particular point? Nay, why is each bee to take delight in its own little part of the combined operation? Why is each to derive pleasure from doing exactly as much as is wanted, and in the direction wanted, in order that when added to what others have before done, and increased by what others are afterwards to do, a given effect, wholly unknown to her and to all the rest, her coadjutors, may be produced?

A. It certainly is difficult to say. I can barely imagine the different bees so formed that some inexplicable gratification may be the consequence of moving in one line, and making one angle, and that any other line or angle whatever may be disagreeable to them. The concert in the operation of animals seems to increase this difficulty much, always supposing there is real concert without any arrangement, communication, or knowledge. No man ever acted so as to make his operations chime in with another's, unless he either had previous concert with that other, or both acted under a common superior, and obeyed his direction; and then the joint operation was that of this superior. But suppose a man were compelled by some feeling he could not account for, and did not at all understand, to go at a given time, to a certain place, and with such speed as to arrive there at a given moment, and were to find another just arrived there, who came to meet him without the former previously knowing of this,—we should have a case similar to that of animals acting in concert, supposing them to do so. There is, however, some doubt of this as to the bees; for Huber has said that they all act in succession rather than co-operate contemporaneously.

B. I really can see no difference that this makes in the argument as to concert. One bee brings wax and does not sculpture; another sculptures and does not bring wax: but the wax-worker brings just as much as the sculpturing bee wants, and at the very time she wants it; also, one works on the face, and another on the back of the same rhomboidal plate; and all so work as never to interfere with or jostle one another, which is the perfection of concert, and can only among men be effected by discipline, which refers the whole of the different purposes to one superintendent, and makes his unity of design the guiding rule and impulse, because concert among the different agents is otherwise unattainable. But I own I can see no greater difficulty thrown in our way by concert than by blind agency—supposing it blind as to both the events, and not merely blind as to the secondary consequence—and your supposition of a first event known and designed, the secondary being hidden from the animal, would, I think, account for a case of concert, as much as for any other operation; for your hypothesis of sensations and impulses would apply to concert. You might say that each bee was induced by the gratification of doing a certain thing, to take a certain line at such a time; that what it did should answer to what some other bee was by the like means induced to do at the same time. I see no difference in the two applications of this hypothesis.

A. I rather think the time makes some difference; at least in rendering an addition to the hypothesis necessary. For though the gratification of bringing the caterpillars to its nest will account for the solitary wasp doing what is also to serve the purpose of feeding its young next season, something more is required than this motive to make one bee act in concert with another; it is necessary that there should be a gratification, not only in doing the thing required, but in doing it at the very moment required; so that both bees must be supposed to feel at the very same instant of time the desire of the gratification in question, and yet without any concert or communication. I hardly see how my supposition of sensations and pleasures or pains will explain this.

B. I all along have seen the greatest difficulty in your explanation; but does this consideration of time increase it materially?—or rather, is it not in all cases part of the riddle which instinctive operations present to us? Thus the solitary wasp acts, that is, according to your hypothesis, feels the given sensation or derives the supposed gratification at such precise time that her acting upon it will suit the time required for the birth and growth of the worm. The bird breeds, — but before laying her eggs, and without any knowledge when she is to lay them, makes her nest, and it is ready at the very time required. Therefore she feels the desire of nest-making at the proper moment. I will admit, however, that there is something still more extraordinary in two separate and independent insects feeling the same impulse at the same moment; and the difficulty is incalculably augmented, if twenty or thirty insects all have the impulse separately, but all at once, so as to act together. Indeed, I cannot help regarding your solution as not only a gratuitous hypothesis, for that it must needs be from the nature of the thing, but one hardly conceivable, and in truth as difficult to suppose possible as any other thing which we can fancy in order to explain the phenomenon—for instance, some invisible power or influence acting upon the animal, or upon the different animals at once. This is not at all more gratuitous, and it more easily explains the phenomenon.

A. Consider if there is really any such essential difference between the case of instinct which we have been considering, and any of the best known operations of men, as well as animals, where we are not wont to speak of instinct at all. Thus men eat from hunger, which they intend to satisfy; but the consequential effect, not intended, is chylification, sanguification, secretion, and growth or sustentation of the body, as well as the effect intended, and immediately produced, of satisfying hunger. The mother eats things which satisfy her appetite, and that is all she cares for; but those things also produce milk, which nourishes her infant, and that she never thought of. The time is also suited by the feeling. The hunger gives the supply when the system wants it; the eating produces the milk when the infant requires it. How does this differ from the other case?

B. Much every way. The difference is wide and marked. In the cases you put, the mental instinct is confined to produce the effect intended; and having produced it, the mind stops there and does nothing more. The powers of matter, its physical qualities, set in motion, do the rest, of course beyond our direct control, and unaided by us as unknown to us. But in the case of Instinct the mind performs both parts—both the things which it knows and intends, and the thing which it neither knows nor intends. The mother eats—nature produces the milk without the least action of hers. But the bee not only gratifies herself (if that is the cause of her architecture) by the structure of the cell, but by her art, by her work, she does the other thing also, that of providing a lodging for her young. It is as if the mother in your supposed case were both to eat intentionally for satisfying her hunger, and at the same time, without knowing or intending it, were to make milk by some process of internal churning. It is as if in eating we at once chewed and swallowed, and also with our tongue or teeth or fingers made chyme, and then chyle, and then blood. It is as if the animal in pairing both gratified his sexual passion and voluntarily made the young by some process of manipulation, though without knowing what he was about, or intending to do it.

A. You must here distinguish a little, or rather you must take into your account a point of resemblance which you are passing over. How can any one even acting with design affect matter in fashioning it or moulding it, except by availing himself of the powers, mechanical or chemical, belonging to matter? If I distil, it is by availing myself of the process of fermentation and of evaporation, and of condensation. If I sow and reap, it is by availing myself of the prolific powers of heat and moisture in the process of vegetation. So even in processes where I seem to do more and nature to do less; if I build, or carve, or weave, it is by availing myself of the qualities of cohesion and gravitation, and of the powers of the wedge in hewing, or of friction in polishing. Do not the animals who eat, the mothers who give suck after eating and thereby secreting milk, in like manner do part themselves, and as to the rest avail themselves of the powers of nature in chylification, sanguification, and secretion? You perceive how much more nearly akin the cases are than you have stated.

B. I am well aware of it; indeed, we are now coming nearly into the controversy about productive labour, which you and I have often amused ourselves with as political economists; when I have always held that it was a far less easy thing than those who discussed the metaphysical parts of that science supposed, to draw the line between productive and unproductive labour, either by including manufactures or only commerce in the latter—and agriculture alone or with manufactures in the former, the productive class. Be it so: I am content, if there be as marked a distinction here as between the labour which produces or moulds matter into a new substance, and that which only exchanges one thing for another; or defends the community, or administers justice among its members. But, in truth, we have, in our present argument, a specific difference, admitting all that you have urged, as to the affections and properties of matter being used by the animal in both processes. The great and broad difference is this. In the one case, as in the wasp carrying the caterpillar to its nest, which she does and means to do, or, if you will, gratifying her senses with the carrying, whatever instruments she works with, she does the thing knowingly and intentionally; she does it by means of gravitation and cohesion, but still it is she, her action, her will, her mind that does it. In the other case, that of leaving the caterpillar in the nest for months, she has done; she quits the work; nothing she does is at all conducive to the operation then performed by nature; but what she did was all that could be done excepting by nature. So the mother eats the galactigenous matter, and then has done; nature does all the rest. But there is this material difference in what the bee or the wasp does,—that she finishes the whole operation voluntarily; it is as if the mother were not only to become gravid, but to prepare the child's clothes and habitation herself, and yet to do this without knowing what she was about, and while she intended to do, and thought she was only doing, some perfectly different thing. If, indeed, you put the case of a person ploughing and sowing for the purpose of strengthening his limbs or amusing himself, and not meaning anything to grow, and also ignorant that anything will grow, and yet choosing the seed which will grow, and sowing it at the right time to make it grow—then you merely put the case of Instinct in other words; and the one thing will be as difficult to explain as the other. And if one man should, by mere blind chance, do this the first time, and some other man, equally ignorant of what the use of thrashed wheat was, should reap and thrash it, and garner it away—and if all men were to do so in two bodies, equally ignorant of what they were about, and yet both chiming in with each other in their operations, and both agreeing with the nature of things, then we should say this is the self-same case with Instinct—but we should add that this could not happen without some overruling power not only giving those men the desire to stretch their limbs, but guiding them immediately how to do it—for there, as here, two designs and only one designer appears, and therefore some non-apparent contriver must exist and work. We may again put it thus—When a man brews or tills, he does something himself, and leaves the rest to the powers of nature. So when a mother eats or drinks to gratify hunger or thirst, she has done; nature does the rest, namely, supports her body and secretes the milk for her young. But the bee or the wasp does the whole. They use the powers of matter, indeed, as the farmer and brewer do, and as the mother does, in the operation itself performed by them, namely, breaking the ground, throwing the seed, steeping the grain, eating the victuals—but the insects finish the operation, and leave nothing to be done. The solitary wasp has completed a cell and provided food; the young have only to eat it. The bee has completed a cell with food likewise. Neither mind nor matter on the part of either insect has anything more to do; the thing they intended and knew all about is done, and in doing that thing they did something else neither known to nor intended by them. They only used the powers of matter in doing the thing they intended. They did not leave any natural powers to do the other thing not intended by them; but they did it also, though unintentionally. Man does what he intended, but he does nothing more —nature does the rest, both where he intended it, as in ploughing or brewing, and where he did not, as after eating to satisfy his hunger. In the bee it is like a whole manufacture completed by the animal, though unintentionally; as if a man were to make a skein of fine lace while he only meant to amuse himself with twirling the bobbins, or playing with his fingers among the flax or the threads.

A. I certainly think we do get to something like a specific difference. But compare the work of the insect with certain chemical processes. If you mix, or if any natural process mixes, certain salts, and the liquor is left to evaporate, there are formed crystals, say hexagons, as accurately as the bee forms her cells. Also certain bodies move in lines which have properties similar to the angles in the comb, as a heavy body falling through the shortest of all lines. There is no doubt a difference here, and a marked one; yet it is as well to consider it.

B. Doubtless there is a difference, and the greatest possible. These forms are assumed, and these motions performed: for instance, a stone falling to the ground in the shortest line, or the planets, all arranged respecting their masses, the direction of their motions, and the inclinations of the planes they move in, so as, according to Laplace's beautiful theorem, to preserve the system of the universe steady, by affixing limits, maxima and minima, between which the irregularities oscillate; all these things are the direct and uninterrupted agency of the property which the Deity has impressed on matter at its creation; perhaps, of the laws which His power perpetually maintains. But they are wholly unconnected with any animal workmanship of any kind; they have no subordinate mind to guide them; nor can any act of ours, or of any animal, affect them. On the contrary, in all our operations we must conform to them.

A. Unquestionably it is so; and this is the distinction, and the broad one. But then it follows from the preceding deductions, that we must consider in the works of Instinct the animal acting as an agent, though ignorantly and unintentionally,—a tool or instrument blindly used to do a certain thing without its own knowledge or design; and the tool being a living thing, the mind is the instrument. In the case of matter, the matter is the instrument blindly serving the purpose by obeying the physical law. In our case the mind is the instrument, and obeys the mental law as perfectly and as blindly.

B. There is one thing, however, always to be considered. We have hitherto been viewing Instinct alone, and arguing as if animals always acted by it, and never otherwise. Now this is quite impossible, at least in the sense in which we have taken the word Instinct. There may be some doubt if we are right in so limiting the term, though I have a very clear opinion that we are. Paley and all or almost all others define Instinct to be a disposition or acting prior to experience, and independent of instruction. But among other objections, there is this one to the definition, that it amounts to saying "an acting without knowledge," and yet does not say it. There may be no experience, and yet no

Instinct, *e.g.*, we may act on the information of others —but then what shall be said of the information given by reasoning; that is, by our inferences from our own thoughts? This is plainly not instruction. Is it experience? If so, the definition seems only to say, that Instinct is anything that is not reason, in other words, that Instinct is Instinct. But I apprehend, when we speak of instinctive operations we always have an eye to some end which is blindly served by the act—some act done by the animal, in which he does what he does not mean, and in doing which he is a blind instrument.

A. How is it when we speak of instinctive desires?

B. I should say we then mean something different from merely animal or natural desires, for that would make everything instinctive. We mean desires which are subservient to some purpose towards which they move: some end beyond the doing the act seems always involved in our notion of Instinct. We do not call mere moving, yawning, stretching, instinctive; and when we speak of sucking or eating, and the desire or power to suck or eat, as instinctive, it is surely with a regard to the subserviency of those operations to support life that we so term them. If they did nothing for our frame, we might call them natural, hardly instinctive.

A. But be this as it may, no one can doubt that animals, if we allow them to have these Instincts, and to act for ends unknown to themselves, have other actions of a kind resembling our own, and quite distinguishable from what we have been calling Instincts; therefore it signifies little whether or not we are right in giving the name to actions accomplishing undesigned and unknown purposes, provided we keep that definition in view. These animals also have other actions, where they both know and intend and accomplish their definite object.

B. Undoubtedly, they have many such in which their operations of mind and body cannot be distinguished from our own. Now whether these are under the guidance of faculties like ours; whether they have reason; whether they have faculties differing from our own in kind, or only in degree—we need not at present stop to inquire. It is quite enough for us that they have two kinds of operations, one which we agree to call Instinctive, distinguished by the ignorance of the object and want of intention; the other both knowingly and intentionally done: so man, acting almost always rationally, also acts in some rare cases unintentionally—chiefly in early infancy.

A. There may be instinctive acts with knowledge, and there may be acts not instinctive without knowledge. Does not this break in upon the definition which excludes knowledge as well as design? Many parts of human conduct seem to be guided by Instinct, and yet with knowledge.

B. This would no doubt overturn the definition, provided it be clear that "*knowledge*," and the "*presence of knowledge*," are here used in the same sense as in that definition. But we must make a distinction. There is a knowledge of some *end* or *object* in view, and a knowledge of the *means* whereby that end or object is to be attained; in other words, of the *mode* of *operating*—of the *process*. There is also a distinction to be taken between instinctive *desires* and instinctive *operations*. The objection you have now made refers to the former—to desires; the latter, the operations, are chiefly referable to the great question respecting the controlling mind, or actual interposition of the Deity, to which we are approaching; but it also refers, in some measure, to the objection which you raise. Knowledge of consequence comes within the description of object or end; and if there be no intention to attain an end actually pursued, there can be no knowledge of it; and conversely, if there be no knowledge of it, there can be no intention to attain it. Take any instance of what you call human instinct, as hunger, or the sexual passion—these are desires, and their gratification may be pursued without any knowledge of, and consequently without any view to, the consequences of making chyle and blood to support the individual, or offspring to continue the race. As far as the mere gratification of the desire or supplying of the want goes, we may be said both to know what we are doing and to intend or mean to do it. We are attracted by our senses, that is, by the effect of our senses on our minds, to do certain things; and this is called instinctive acting,—I apprehend incorrectly. It is *natural* desire, but why instinctive? When we say Instinct, do we not mean something beyond this? Desires may be subservient to Instincts: but are they all we mean by Instinct? They may lead to the attainment of a certain end; they may be the way in which Instincts operate: but are they themselves Instincts? If two foods are presented to an animal, a man for example, who knows nothing of either; and he is impelled, without knowing why, to take the one and reject the other, and the one is wholesome and the other a poison; we at once call this the operation of instinct, which some define to be knowledge without instruction or experience, but which I have wished rather to call mental action without knowledge, or at least independent of knowledge. So in Galen's beautiful experiment on the kid just born, having been taken out of the mother, and which of course had never sucked, when, upon many shallow pans with different liquids being placed near it, the animal preferred at once the pan containing goat's milk. If the reason for the preference is some greater gratification of the senses, or that the one food is pleasing, for instance, in smell fragrant, and the other offensive, this may be the mode taken by nature to make Instinct operate according to your former hypothesis, which we have been discussing at large; and we certainly cannot tell that such may not, in all cases, be the mode taken by nature for working to the same end. It seems, however, eminently unlikely that the whole operations of bees, for example, should be owing to the pleasure their senses receive from one particular form and proportion alone, and a repugnance to all others, because of their being disagreeable to those senses. But do we not, in all cases, mean, by using the word Instinct, to point out the unknown connexion between the thing done and something else of which the animal—the agent—is not aware? I grant you that we speak of Instinct of hunger and Instinct of sex; but is not this only a way of saying, and do we not mean, merely desire of food or sex, the gratification of which is a natural propensity, and known and felt by us to be such? Thus it is an Instinct which makes animals propagate their kind while they merely mean to gratify their passions, and which enables them to prepare a nest, and have it quite ready at the very time they are to want it for laying their eggs in. We always seem to have the *motive*, the *end*, and the *blind instrumentality* in our view when we speak correctly of Instinct. I may intend to do a thing, and know both the object in view and that portion of the operation or process which depends on me—*e.g.*, to eat for the purpose of making chyle. My ignorance of that process, with which I have nothing to do, would not make the operation of mine be called an Instinct. Indeed, even if I eat to satisfy hunger, without any design of supporting the system, this act is not instinctive, except in so far as doing and meaning one thing, I am doing another thing ignorantly and unintentionally.

A. I think we have got as far as we can in these preliminary discussions and observations of Facts, and may now proceed to Theorize and infer.

B. However, we are come, or coming to a part of the subject where we should be among our books; for we shall now have to look at them in proceeding farther. At least, it is as well we should observe what has been held on this matter by philosophers. So we had better adjourn for the present; and resume our conversation in the library, if indeed you, who are accustomed to Althorp and Spencer House, can condescend to call anything in this part of the world by that name. We commonly, from feeling this modesty, name it the Book-room.

A. And I dare swear, also from your love of the Saxon idiom.

B. Possibly; though I would that our good old English never suffered more havoc than by calling Book-rooms Libraries. I expect to outlive it, as Serjeant Maynard said he had nearly done the law, with the lawyers.

BOOK OR DIALOGUE II.

INSTINCT.—(Theory.)

Having thus far carried on our discussion in the open air, we removed, towards the afternoon, to the library —"cum satis ambulatum videretur, tum in bibliothecâ assedimus"*—and there conveniently pursued the subject, which greatly interested us both.

B. The manifest difference between Instinct and Reason which we have been observing, and its regular and constant action, always the same, and never improved, but never different, indeed apparently incapable of improvement, was probably the consideration which induced Descartes to consider animals as machines.

A. I am aware that this is commonly said of him. But I know not how that great man could really have held so untenable a position. Did he really consider them as mechanical contrivances—as mere physical substances, without anything answering to what we call Mind?

B. He is always so represented; but when you examine his own statement closely, you really find that this is an exaggeration, and that his doctrine differs not very much from that commonly received. As has oftentimes happened to others, his sentiments are rather taken from the statement of them by those who were controverting them, than from his own words.

* "When we thought we had walked long enough, we took our seats in the library."—*Cic. de Div.* ii.

A. Where are they to be found?

B. Look here—you have them in the short treatise on Method, the introduction to his work on Dioptrics and Meteors. He dwells on brutes having no gift of speech, which yet requires very little reason, he says; and therefore he concludes not that they are less rational than man, "sed plane esse rationis expertia."* Thus far no doubt can exist; he only gives a very common opinion on the subject, though an opinion controverted by some, as I shall hereafter ask you to discuss: but it forms a head distinct from our present inquiry. But a little way farther on he proceeds to illustrate his position in a manner which has given rise to the notion in question. "They do many things even better than ourselves," he says, "but this does not prove them to be endowed with reason, for this would prove them to have more reason than we have, and that they should excel us in all other things also—but it rather proves them to be void of reason, and that nature acts in them according to the disposition of their members, as we see a clock, which is only composed of wheels and weights, can measure time better than we can with all our skill." He goes on to show that the interests of virtue are greatly injured by the belief, not that brutes have souls, but that they have souls like our own—"brutorum animam ejusdem esse cum nostrâ naturæ,"—and that therefore we have nothing more to hope or fear in a future state than flies or ants; whereas he had shown our souls to be by their nature independent of the body, and therefore not mortal like and with it. All this you perceive is anything rather than the doctrine that brutes are mere machines.

* *De Methodo*, 36.—"Istud autem non tantum indicat bruta minore vi pollere quam homines, sed illa plane esse rationis expertia. Videmus enim exiguâ admodum opus esse ad loquendum."—["But that not only indicates that brutes have less power than men; it also proves them to be void of reason. For we see that very little reason is required to enable men to speak."]

A. But where do you find the adversary's representation of it which you mentioned?

B. Here, in this other and very curious volume, containing his Correspondence with many learned persons, and some less learned, as Christina, Queen of Sweden, and our Princess Elizabeth, the Electress Palatine and stock of our present Royal family, to whom he writes, among other letters, one on her brother Charles the First's execution—which, to console her, he praises as more glorious than an ordinary death—"pulchrior, felicior, et dulcior."*

A. Does the Princess enter on the question of animals?

B. No; she seems to have been ailing with fever, and having been light-headed, she applies to the philosopher to explain to her how in the night she felt an irresistible desire to make verses: this he courteously explains (after saying it reminded him of a similar anecdote related by Plato, of Socrates), that it is owing to the agitation of the animal spirits, which in weak brains produces madness, but in strong ones only a genial warmth, leading to poesy, and thereupon he holds her Serene Highness's case to be "ingenii solidioris et sublimioris indicium."†

A. Upon my word, I shall begin to think a person who could thus theorize as well as flatter about animal spirits and Serene Highnesses, was capable of shutting his eyes to the most ordinary facts, and believing brutes to be machines.

B. Do not undervalue this great man: he is the true author of all the modern discoveries in mathematics. He made the greatest step that ever man made since the discovery of algebra, which is lost in the obscurity of remote ages: I mean his application of algebra to geometry, the source of all that is most valuable and sublime in the stricter sciences and in

* "Finer, happier, sweeter."—*Epist.*, Pars I., Ep. xxvii.

† "The proof of a more solid and more lofty understanding."

natural philosophy. But assuredly his physical and psychological speculations are much less happy; although it was no mean fame to be the author of a treatise, the answer to which was the first work ever composed by man—Newton's 'Principia.' But I was coming to the controversy on Instinct. An ingenious clergyman of Cambridge, Henry More, objected to the doctrine of the great philosopher, as laid down in that treatise to which we have been referring, on Method; and he began by describing the doctrine as denying sense and life to brutes. He speaks of Descartes' genius, "chalybis instar rigidum et crudele, quod uno quasi ictû omnium ferme animantium genus vitâ ausit sensûque spoliare in marmora atque machinas vertendo."* This he repeats in various ways, and argues against, as the doctrine of Descartes.

A. Nothing in what we have read out of Descartes' own writings justifies this. Is there any other passage to which More can allude?

B. He refers expressly to the passage in the 'Tractatus de Methodo,' and discusses the argument there given from the want of speech. But there remains a letter of Descartes to a certain great personage (ad Magnatem quendam), in which he repeats the doctrine of the treatise at somewhat greater length, but using the same comparison of a clock, and using it as a comparison. His whole contention is, that they, the brutes, have not reason like us, which he terms sometimes "intellect," or thought—"intellectum vel cogitationem." But that he means reason, and does not mean to assert that brutes are machines, seems plain from this, that in the same passage he allows them natural cunning, or craft, as well as strength—"imo et puto nonnullos (animantes) esse posse quæ naturalibus astutiis instructæ sunt quibus homines etiam astutissimos de-

* "Rigid and heartless like steel, which, as by a single stroke, can deprive almost all animals of life and sensation, turning them into marbles and machines."—*Epist.*, Pars. I., Ep. lxvi.

cipiant."* This is anything rather than describing them as mere machines.†

A. But what does Descartes reply to his correspondent's letter, in which he represents that to be his doctrine? Does he object to Mr. More's statement?

B. Why, singularly enough, he does not in distinct terms repudiate it, though this may be owing to his supposing that, as he had used the comparison of the clock, Mr. More is also speaking in the same terms, especially as Mr. More had professedly used figurative language, and spoken of Descartes' cutting off all animals as with a sword. But he speaks certainly in this answer‡ more strongly than elsewhere. "I have diligently inquired," says he, "whether all the motions of animals came from two principles, or only from one; and as I find it clear that they arise from that principle alone which is corporeal and mechanical, I can by no means allow them to have a thinking soul. Nor am I at all hindered in this conclusion by the cunning and sagacity of foxes and dogs, nor by those actions done by animals from lust, hunger, or fear; for I profess to be able easily to explain all these things by the sole conformation of their limbs." He adds, that though he sees no proof of the affirmative proposition (of their having a thinking principle), yet he also admits there is no proof of the negative; and he then comes back to

* "Nay, I also think there may exist some brutes endowed with natural cunning to deceive the most cunning of men."—*Epist.*, Pars. I., p. 107.

† He afterwards, in the same letter, says, that although brutes do nothing to show they can think, yet it may by some be supposed that as they have limbs like our own, so thought (cogitatio) may be joined with those limbs, as we know it is with our own, although in them the thinking principle (cogitatio) may be less perfect than in us. "Ad quod," says he, "nihil est quod respondeam nisi quod si illa cogitant ut nos, animam etiam ut et nos immortalem habent, quod non est verisimile;" ["To which I can only answer, that if they think as we do, they must also have, like us, an immortal soul, which is not probable;"] and he proceeds to say, that oysters, sponges, and other imperfect animals, can hardly be supposed immortal.

‡ Pars. I., Ep. lxvii.

his favourite topic of its "being less likely that worms should have immortal souls, than that they should move like machines;" and again refers to the want of speech.

A. How any man who ever saw dogs in a field pointing, or greyhounds chasing a hare, or still more, dogs sleeping and manifestly dreaming without any external object to excite their senses or motions, or who had observed birds taught tunes, could ever suppose them mere corporeal or material mechanism, things made of dead matter and without life, I cannot comprehend.

B. The best of it is that he positively affirms they have life. The letter I have just been reading from, and in which his doctrine, if anywhere, is stated the most explicitly, concludes by warning Mr. More not to suppose he denies them life; and it is remarkable that he uses the very words *vita* and *sensus*, which Mr. More had represented him as refusing to brutes—"Velim tamen notari me loqui de cogitatione, non de vitâ vel sensû. Vitam enim nullo animali denego."*

A. Then what does he mean by life and sense?

B. He goes on to tell you, "utpote quam in solo cordis calore consistere statuo;" mistaking the indication or effect of life for life itself. He adds, "nec denego etiam sensum, quâtenus ab organo corporis pendet."† Now, can it be that Descartes really supposed he had taken a tenable distinction here between mind in man and in brutes? Or that there could be any perceptible difference between a machine endowed with life and sensation, and capable of imitation, of learning, and of much cunning—and a body animated by a mind? To speak of sensation as depending upon

* "I would have it borne in mind, however, that I am speaking of thought, not of life or sensation, for life I deny to no animal."

† "Nor do I deny them sensation, in so far as that depends upon the organs of the body."

the corporeal organs is either unintelligible or it is a begging of the question, and the very same definition might be given of our own sensation—nay, is given of it by the materialists, who hold our mind to be the mere result of a physical organization. Yet with these Descartes differs more indeed than with all others.

A. I cannot help thinking, on the whole, that it is very possible this great man may have only meant to deny the brutes a reason, or mind like ours, a power of ratiocination, and not to consider them as mere machines. But I am clear of one thing, that if he did mean the latter, a more untenable doctrine never was broached upon this, or indeed upon any other subject.

B. We may, therefore, I conceive, pass over this theory altogether. But another and a greater man has been so pressed with the difficulties of the subject, that he has recourse to a very different supposition, and instead of holding the Deity to have created brutes as machines without any mind at all, he considers their whole actions as the constant, direct, and immediate operation of the Deity himself. Such is the doctrine of Sir Isaac Newton, which is saying enough to prevent any one from hastily rejecting it, or rashly forming his opinion against it.

A. Does he not mean merely to derive the actions of brutes from a perpetually superintending and sustaining power of the Deity, as we ascribe the motions of the heavenly bodies to the same constantly existing influence? He probably only means that the brute mind, having been created, is as much under the Divine governance as the material powers, qualities, and motions are: in other words, that mind was created, and matter was created; and that still the actions and passions of both are constantly under the guidance of the Creator. So that Sir Isaac Newton would no more deny the separate existence of the minds of brutes, than he would the separate existence of their bodies, or of the heavenly bodies.

B. Here are his own words. The passage occurs in the famous 31st Query, or General Scholium to the 'Optics;'* and you see that, after recounting the structure of animal bodies as proofs of design, he adds, "And the instinct of brutes and insects can be the effect of nothing else than the wisdom and skill of a powerful, ever-living agent, who, being in all places, is more able by his will to move the bodies within his boundless uniform sensorium, and thereby to form and re-form the parts of the universe, than we are by our will to move the parts of our bodies." He proceeds to guard the reader against a supposition of the Deity being the soul of the world, or of brutes, or of His being composed of members or parts, stating that He only "governs and guides all matter by his prevailing power and will." So that you see he draws the distinction between the mind or will of men, which influences the motions of their bodies, and the influence which moves brutes; plainly enough referring the latter to the Deity himself, as the *primum mobile*, or actuating principle; for he allows that the kind of ubiquity or universal action to which you refer applies to our bodies, and I presume to our minds also, which were created and are sustained by Him. Of that no doubt can exist, because elsewhere he has laid down as clear this ubiquity, called, as you know, *essential* ubiquity, to contradistinguish it from *potential* or *virtual*. You find this plainly stated in the 'Principia'—here is the celebrated General Scholium: "Omnipresens est non per virtutem solam, sed etiam per substantiam"—"In

* There is nothing more admirable for extent and generalization of view than this 31st Query. The happy conjecture respecting the nature of the diamond in the 2nd Book (Part II., Prop. 10), does not surpass the wonderful sentence in the query, where Sir Isaac Newton classes together, as similar operations, respiration, oxydation, and combustion. These have since been discovered to be the same process. In Sir Isaac Newton's time, their diversity seemed as great as that between the diamond and charcoal.

ipso continentur et moventur universa, sed sine mutuâ passione."* Therefore it is quite manifest that, in here treating of Instinct, that is, of the operations of animals, he considers the Deity's action as different from that general direction which he ascribes to Him over matter and mind by His essential ubiquity. In other cases He acts on matter and mind, and in the case of mind, He acts on matter mediately or through the agency of mind, which mind He moves. But here He acts, according to Sir Isaac Newton, directly on matter, and is the moving and acting principle of animals; and such has generally been the construction put upon his words as you have them here in the 31st Query. It has been so stated by so popular a poet as Pope, and also, though with less precision, by Addison. The former takes the distinction, in his 'Essay on Man,' between brutes as only having volition, which in them acts for both willing and reasoning: while men have the double faculty. He expresses himself with his wonted felicity:—

> "See then the acting and comparing powers,
> One in *their* nature, which are two in ours;
> And Reason raise o'er Instinct as you can,
> In this 'tis God that acts, in that 'tis Man."
>
> *Essay*, *Ep.* iii.

Addison in his 120th 'Spectator,' after giving many instances in which he jumbles together Instinctive and Intelligent operations, concludes with the remark, that "they can no more be explained than gravitation can; and come not from any law of mechanism, but are an immediate impression from the first mover, and the Divine energy acting in the creature."

A. This dogma of Newton is certainly great authority—the greatest human authority. For it is the opinion—and, regard being had to the awful nature of the subject as well as the contemplative and religious

* "He is omnipresent, not virtually alone, but substantially"—"In him all things are contained and moved, but without mutually affecting each other."—*Principia*, lib. iii., Sch. Gen.

nature of the man, it is probably the well-considered opinion—of the greatest inquirer into nature that ever existed, and whose conjectures have been almost as happy, and are certainly quite as marvellous, as his complete discoveries.

B. Observe, too, that it is the opinion of his maturer years. The Scholium to the 'Principia' was added in the later editions—when written does not clearly appear, but the second edition was published in 1713, and the third as late as 1726. The 31st Query to the 'Optics' was added at a time which can be fixed better. The first edition of the 'Optics,' published in 1704, had not the queries. The second, published in 1717, had them; and the third edition was corrected by the author's own hand a short time before his death; from which corrected copy the one I am now citing was printed in the year 1730, after his decease. But as he first published this passage in 1717, and was born in 1642, he was then in his 75th year, and had long before made all his discoveries.

A. I quite agree that as far as mere authority goes, no opinion ever had so great a weight—nevertheless we have the same illustrious man's authority, and example too, to teach us that it is by our own reason alone that we ought to be guided in philosophizing, and we must bring to the test of that canon even HIS best considered opinions.

B. This I of course freely admit. Let us, then, examine a little this doctrine of immediate interposition —which regards the work of the bee, for instance, as the direct and immediate operation of Divine wisdom and power.

A. I need hardly warn you against being seduced by another bias, as powerful as Sir Isaac Newton's authority—the disposition we must have, if possible, to believe in a doctrine which, by exhibiting the finger of God as perpetually moving and working before our eyes, seems to bring us constantly into His presence, as if we saw a perpetual miracle wrought, and almost enables us to commune with the Deity, as the Patriarchs did of old. The gratification to us, as men, of reaching this position, should not make us, as philosophers, open our ears the more readily to any unsound or inconsistent reasonings, assume facts on slight grounds, or, passing over flaws in the argument, receive easily erroneous conclusions from what we see.

B. Again I entirely agree with you. Far from making greater haste to reach a position so delightful, I should take the greater care of my steps, that I might not slip and fall by the way: for that the road is slippery, the light glimmering, and the route over high ground, leading through precipitous passes, must, I think, be admitted freely. But let us step on cautiously as we have hitherto done.

A. We left off with the deduction that brutes act from a principle, a thinking principle, a mental principle, something different from their bodies and from surrounding objects, but that they act towards an end of which they are ignorant, and accomplish that end without design, though very possibly they may also in so acting accomplish some intermediate end of which they are aware, and which they intend to attain.

B. We may add another thing to the proposition. The end which they accomplish blindly and instinctively is far the more important of the two, admitting that there is another and intermediate one. For, suppose your theory to be correct, that the solitary wasp gratifies some sense in carrying caterpillars and the bee, in making hexagons and rhomboids, it is plain that this is a very trifling matter; it neither feeds, nor clothes, nor lodges her, nor her brood; whereas, the purposes to which those works are subservient are the continuation of the species of the insects respectively—the greatest and most favourite end in nature.

A. True; and you may add another thing, which I allow, even if my theory be ever so certainly correct

—that the only possible use of the intermediate end is the accomplishment of the other end—for if you grant me that the wasp carries caterpillars, and the bee makes geometrical figures, to please themselves, or gratify some sense, it is of no importance that either should receive that gratification: its only use is the unknown and unintended consequence of providing for the unborn issue.

B. We are now then arrived at a very important height, from whence we may survey the subject correctly and advantageously.

A. Let us be quite sure that we have left no obstructions, or rather that we have passed over nothing material—that we have left no objections in our rear, which may rise up and mock any inference we now draw. For instance, are all our facts clear? As to the bee's architecture, some have questioned the theory. I have heard it said that what seems so perfect a structure, and so judicious a dividing out of the space, so as to save room and work and material, is only the necessary consequence of placing a number of cylindrical or globular bodies together; that if you blow many soap-bubbles in a basin they will, by their weight and pressure, settle into hexagons.

B. There never was anything more absurd than what some, calling themselves philosophers, have said without a moment's reflection on this subject. No less a name than Buffon may be cited for such nonsense. There are two decisive answers:—*First,* the soap-bubbles will not make hexagons, although your eye may see straight lines formed by their intersections, but not one hexagon the least like the bee's will you find in all the foam; and *next,* there is not a single globe, or cylinder, or any figure like it ever made by any bee. Huber has seen them, or rather had them carefully observed, when at work; they first make a groove, and then form its walls into planes, and all the rest is a making of planes and angles one after the other without any circular figures at all. So some one finding the eye of the bee to be a net-work, when greatly magnified, and each mesh a hexagon, thought he had found out why the bee works in that figure. To which the answer was obvious, that men and other animals having circular pupils should, by parity of reason, work in circles. But another answer was just as decisive; that the light entering by a hexagon almost infinitely small no more helps the bee to that figure than if it entered by a circle or a square. Its paws and feelers are to work. Nay, suppose even it had a small pattern hexagon ready made, would its working a large one on that model be at all less wonderful? Not to mention that the hexagon is not the greatest wonder; the rhomboidal bottom of the cell, and the angles which its three plates form with each other, and with the walls, are the wonder, and no one pretends to account for that. I pass over the form of the limbs; nothing can possibly be deduced from them in the smallest degree fitted to aid the bee in her marvellous work.

A. Have not some sceptical inquirers thrown other doubts upon the mathematical part of this great wonder? I think I have heard something of the kind, as if Maclaurin, or whoever was the discoverer, had rather been fanciful, or over-refining, and that the bee had turned out to be not so good a geometrician as they had supposed.

B. Here is a sample of those doubts—though they are not indeed, like Newton's sound conjectures, stated with the modesty of doubts—but somewhat dogmatically. It was the celebrated Maraldi who first measured the angles, and found them to be 109° 28′ and 70° 32′ respectively. Réamur afterwards set a young mathematician, pupil of Bernouilli, called Kœnig, to find what were the angles that made the greatest saving of wax, and the result was by his analysis 109° 26′ and 70° 34′, being within two minutes of his own measurement, which measurement he had not communicated to Kœnig. But it turns out that the bee was right and the analyst wrong: for by solving the problem in another way I find that he erred by two minutes; and other mathematicians, with whom I have communicated, distinctly find the same thing, and we have also found how the error crept in.*

A. These angles must have been very nicely measured; for the difference of two minutes, or the 2000th part of the lesser angle, is very small indeed. How were the angles first ascertained?

B. Maraldi was a most accurate observer, and he gives the angles, as I have stated, 109° 28′ and 70° 32′; and he gives them to differ with the result of Kœnig's calculus, which was made after Maraldi had measured—so he could not have fancied the amount. But I have reduced it from measuring an angle to the easier operation of measuring a small line. If those are the angles, then it follows that the breadth of the rhomboid is exactly equal to the side of the hexagon, and you find it appears to be so. Also, if those are the angles, the rhomboidal plates are inclined to one another at the angle of 120°, that of the hexagon; and you find they do not differ when you place them together, one within the other. However, I admit that this is not a very close admeasurement of such small differences; and I presume Maraldi must have employed a micrometer. I have used one to compare the breadth of the plates and sides, and I certainly can find no inequality. At all events, the bee seems entitled to the benefit of Maraldi's previous measurement, which had been thought to put her in the wrong, now that the analyst and not she has been found in error. This, however, is nothing to what follows. A Berlin

* See this fully explained in the experiments and demonstrations relating to the comb in this volume. There is some contradiction in Maraldi's statement, *Mém. Acad. des Sciences*, 1712, pp. 310-312; but the above measure has always been considered to be that which he intended to state as his result.

academician, thinking, I suppose, to do a kindness by Frederic II., objected to the bee, that though, if the dimensions of the cell be given, the saving is as I have stated, yet there is such a great waste of wax arising from those dimensions as proves the saving of wax to be no object. He sets himself the problem of what he calls a *minimum minimorum;* namely, to find the proportion between the length and breadth of the cell which saves most wax; and he finds it something quite wide of the actual proportions. Now, I went over this analysis, and again found the bee right, and the philosopher at fault; for he had wholly left out the hexagonal covering of the cell's mouth, which, whether for brood or honey, there always is; and I found the actual or bee's proportions to save more than the academician's, when this was taken into the calculation. I moreover found the sides to be so much thinner than the bottom, that a shallow and wide cell would have cost more, even independent of the covering at the mouth. Again, he admits the form chosen to suit the bee's shape, which the form he calls a true minimum never could; but I show that it saves wax as well. Lastly, I have solved another problem of a like kind, namely, to find the angles that save most of the fine or difficult work, which is the angular or corner-working evidently, and that also is the thickest part of the work necessarily. I find the solution gives the very same angles which the bee uses, and which also save wax in the other view. So that she has hit upon the very form which in every respect is the most advantageous, and turns out to be on all grounds right—as indeed we might well suppose when we recollect who is her Teacher.

A. All this is most satisfactory, and it was worth stopping to state it. However, as we have made a pause before our next advance, it may be just as well to stop for a moment longer in order to consider what the bee's operation really is. How we should go to work had we to build cells is plain enough. Suppose we had discovered, which we should do by mathematical investigation, the proper form, the due proportion of the width to the length, and the proper angles of the bottom or roof—then we should have drawings and plans; and by these we should either cut our planks, if the structure were of wood; or if it were of stone, which more resembles the bee's materials, and is, be it observed, much more difficult and complicated to work with, we should, by those plans and by models or frames, run our courses. It would be a nice and difficult work to make this masonry, and would require the builder, both in hewing the stones and in putting them up, to follow the details of the plan in its parts, and without any regard to the general figure or result. He would be wholly unable to succeed if he looked to that; all his building would be awry and out of the required figure; his only chance is to make his plan exact, and his model-frames suit it; and then he has instruments and tools, plumb-lines, squares and plumbs together, in order to raise his perpendiculars. By these he proceeds, for he cannot trust his eye or his hand a moment beyond the mere adjusting his work to his instrument and his plan. Now the bee confessedly has neither plan, except what is in her head; nor any model at all whereby to guide her hand; nor any instrument to adjust her work to the plan in her head; nor any tool to work with except her paw and her feeler, which is as her eye in doing the work. Then how does she work?

B. Certainly, this is a most important consideration. We cannot trust our eye or our hand an instant. We have no exact perception of the line, and no steadiness in pursuing it. We have recourse to plans and instruments because we cannot form our lines by volition, that is, by having a form in our mind and by making our hands follow that form. We therefore must first lay it down sensibly, and then guide our hands by material means. Thus we have no power of forming a dome, an arch, or a circle, or a perpendicular, or a level, or even a straight line at all, or any one line or form which we conceive in our mind. Far from being able to follow these lines in great works, as roofs and walls and excavations, we cannot even represent such forms on a sheet of paper by our handiwork. If we could do this we should work like the insect, who acts immediately, and not through the instrumentality of means. Unable to execute any purpose of our minds, as she does, we have recourse to instruments. We endeavour, as far as we can, to reduce everything to a physical or material process—to exclude mental operation or agency altogether—to make the whole a material, or as we call it, accurately enough, a mechanical operation. Reason no doubt has taught us to do so; but it has taught us a general rule; and there is little or no reason, little or no operation of the mind, in its application to the particular cases. On the contrary, the use of the rule or method is that it precludes the operation of the mind as much as possible, and makes the whole physical, or nearly so. To take an instance —we reduce, by engraving or printing, the whole operation of drawing a picture, or writing a page, to turning a lever, which does the work for us. So in building, though there is less mechanical facility, we guide our hand by the instruments employed and the lines drawn, making the operation as mechanical, as little mental, as possible. The bee's operation is all mind together. She has no plans, no instruments, no tools. It is as if by waving our hands among plastic materials we formed walls, and domes, and columns, and never deviated a hair'sbreadth from the perfectly accurate plan. I am very decidedly of opinion that this essential difference between the works of Reason and Instinct is of the greatest importance to our inquiry: for nothing can more show the peculiarity of the instinctive operation; or more prove that the mind of the agent is as it were the machine, and the instrument, to perform the work, and to perform it with an unerring certainty and with absolute perfection.

A. Does this, which appears to me, as it does to you, a most important consideration, bring us at all back towards the ground of Descartes, which we had passed over as forming a position wholly untenable: I mean, that the insect is a mere machine, fashioned by a perfectly skilful mechanic, and wound up to perform the functions which he designed?

B. Certainly not. The proposition which we have just been deducing from the facts is rather of a kind the very reverse: it affirms that the insect's mind performs the whole operation; it makes the insect's mind the machine, if I may so speak. But let us see to what it also leads or seems to lead us. We perceive there is mind at work, action exerted, effect produced; but we see that the mind is quite unconscious of the effect, and that the action works to a purpose which the mind never contemplated. There is a thing done, an important and rational thing done, but done by an agent who neither intends nor knows anything about it. Here there is design, but there is no designer—an action and an object no doubt; but that action performing, besides what the agent intended, knew, and did, something else (and that something the only important thing), which the agent neither knew nor intended, and cannot possibly be said to have done at all. This by no means leads us back to Descartes' position, but does it not lead us to Sir Isaac Newton's? The design is manifest; the action is perfectly and surely adapted to it; the purpose is with singular regularity effected; must there not be a designer, and who can that be but the Deity? There is none other that can be suggested even. Must it not be He?

A. Doubtless in one sense it must, as he is the designer of all we see. But how is he more the designer here than he is of the motions of the heavenly bodies, or the growth and germination of plants?

B. As thus. In those cases there is nothing but matter affected, or acting; whatever laws were originally imposed on matter are followed; whatever qualities first communicated to it are displayed: all is material. There was design in the original formation of it, in the prescribing those laws, and impressing those qualities. That design these bodies fulfil; they conform to the primeval and original intention of their being. But there is no renewed design, no repeated intention, no special and particular disposition in each case of action. The Deity made a stone, and made the earth, so that the stone falls to the ground by virtue of the general rule of their formation. He is not to be referred to; he needs not interfere each time the support is withdrawn from the stone, in order to direct the path it shall take. If on that support being withdrawn some interposition were required to decide how it should go—for instance, whether it should stand still or not—although it be admitted, that if it move it can but move in the straight line downwards, the case would more resemble Instinct, though even here it would be different; for it is as if each hair'sbreadth of the stone's motion required a new action to carry it on in its course.

A. The Deity created matter so as to obey in each case certain general laws: so he created mind in like manner to obey certain laws in each case. Wherein do the two facts differ, the fact of material and the fact of mental action?

B. As thus. The moving power is wanting in the one case. The law is that matter shall act in a certain way, and mind in a certain way; but is it the mind of the insect that acts when the whole mental process is wanting, namely, the knowledge, thought, and will? Its mind acts, subject not only to a general law, but to a particular impulse each time. Who gives the impulse? Besides, your doctrine of the Deity creating the insect's mind such as to act so in given circumstances, applies quite as much to our Reason as to its Instinct. Let me, however, put a case: suppose we saw a man born blind, to our own knowledge, without any teaching, and without ever having tried it before, move his fingers in the design of giving them exercise, as to keep them warm, &c., but holding a pencil in them, and by the same act producing, unknown to himself, a beautiful and finished portrait, of perfect resemblance to the original: or suppose we saw a man who had been born and lived in a foreign country, and was utterly ignorant of our language, of which he had never heard a word, write a letter in correct English, or a beautiful copy of verses, while only meaning to try whether a pen was well cut, or the ink rightly made—these acts are quite analogous to the Instinct of bees. Nay, we may take a nearer case, and suppose a man who never had learnt mathematics, and did not know a line from an angle, to solve on a slate a problem of great difficulty with perfect and unerring accuracy, and this while he was only trying the pen and the slate; and suppose he then applied this solution to the combinations of a perfect time-keeper, while he thought he was only cutting off the superfluous pieces of two lumps of brass and steel of which he intended to make weights, he being wholly ignorant of what a time-keeper meant. There is nothing more strange in this than the bee's architecture. It is indeed exactly, and in all its parts, a parallel instance. In all such cases (the extra thing done, and not known or intended, being far more difficult and more important than the thing intended and known to be done), we should at once pronounce that there was a miracle, because of the thing done being without the possibility of the apparent agent doing it unassisted, according to the ordinary laws of nature. In other words, want of power in the immediate agent compels us to believe in the interposition of another agent having the power. There is *dignus vindice nodus*, and we call in the *vindex*. This is the foundation of all belief that there must be supernatural agency where the laws of nature are suspended. But in the cases put there is not only want of power, but of design. If want of power in the apparent agent drives us to suppose or infer the action of another unseen agent, want of intention or design should drive us to infer the intending of another designer, and want of both power and intention should make us infer the thinking of a planner who intends, and the action of an agent able to perform the work: in other words, to infer the interference of one who has both the will and the power, each of which is wanting in the immediate or apparent agent.

A. In the case you put of a miracle, there is a single instance, and because it is solitary, we say the laws of nature are suspended, and we call in supernatural aid. In the case of Instinct, it is the constant course; it would be a suspension of the law, and a miracle, were it ever otherwise. It is as much part of the law of nature that the animal should do the thing in question without intending it, or knowing how he does it, nay, that he does it at all, as that man should do it knowingly and intentionally, or that the animal should knowingly and intentionally do those other things in which he acts rationally, and not instinctively. Therefore this case does not resemble a miracle.

B. The case of a miracle I did not put in this way or with this view at all. I do not say that the instinctive act of the animal, or of man when he acts merely from Instinct, as he does, though most rarely, are to be compared with miracles as being suspensions of natural law; but only that the same reason which makes us, when arguing from such suspension of natural laws, conclude that some power has interposed different from the powers acting under those laws, requires us, when arguing from the acts done by the animal without either design or power, to conclude that some agent has interposed of power sufficient, and some intending and designing being of will fitted, to do the acts in question. Suppose, to put again my first case with a variation, we saw a blind man draw a likeness as often as he stretched his fingers with a pencil in them, and every foreigner of a certain class write good English verses as often as he tried a pen, and every man of a particular description make excellent time-keepers as often as he cut away the parings of the metal balls he was forming into weights—we should in every such instance of these general laws (as they could now be) have a right to draw an inference of one and the same kind. What would that be? Manifestly that here the same thing was done without knowledge or intention, which in the other class of cases (those where reason and experience operated) was done by means of knowledge, and with intention. For the gist of the question and the whole difficulty is this—that we have two classes of cases—the same act done in the one class knowingly and intentionally, and in the other, without knowledge or intention—and as in the vast majority of all acts taken together of all kinds of agents, we can see no such thing—indeed, cannot form the idea of such a thing—as an act without power and will to do it, or a thing resulting to all appearance from intention, because in itself such a thing as we should do if we intended a given thing, and yet without any Being to intend, so we are compelled to infer the power, that is, the knowledge of the intender.

A. Indeed, it must be observed, that when we speak of a miracle we mean, and commonly do mean, two things, not only the fact seen of the laws of nature being suspended, but the inference drawn of some power interposing capable of suspending them, and therefore above them, and having sway over them; and this inference arises from the necessity under which we feel of accounting for the phenomenon observed by supposing an adequate cause; in short, from our being unable to conceive anything done without a cause. The ordinary powers with which we are acquainted fail to account for this event, and we therefore infer another power to be in operation.

B. Certainly it is so; but then this is precisely the case with Instinct, as compared with the other phenomena, namely, those things done with both knowledge and design on the part of the agent, that is, things in doing which the agent is known to us, and intends, and knows what he does. Suppose, according to the case so well put by Paley, in the beginning of his book,—suppose you find on a common a watch going and producing manifestly an effect according to its construction; this would show a design in its maker; but only a former, or bygone, a spent and executed design. Nothing would be seen designing or intending, as it were, before your eyes. Suppose, then, you saw the watch, or other machine, making a second and third machine, but not by mechanical contrivance—for that, too, like the case put by Paley, would still only be evidence of a former, or bygone, or executed design,—you must suppose a new watch to be made before your eyes without any material agency, or, which is the same thing, made by a machine wholly incapable of performing the operation itself. Then you would necessarily infer from these the existence of some being, some thinking and designing and skilful being, capable of doing what you saw, that is, of making the machine; and you would suppose this just as much if you saw an incapable body performing the operation, as if you saw the operation performed without any visible or sensible material agent at all. Now, this is precisely the case of the bee: it is the incapable body or being.

A. May it not all be said to be only another inference of original and general design, as we deduce that conclusion from the structure of the limbs of animals, and the functions suited to that structure which those limbs perform?

B. Even if it were so, there is the broad distinction between mere mental and mere physical agency; and the difference between the inferences to which those agencies respectively lead. But I apprehend the difference is greater still than this. The two cases are not at all the same or alike, hardly even analogous. We never know of matter, or any combination of material parts, acting or affected but in one way. We have not matter with, and matter without, gravity, cohesion, impenetrability. But if the phenomena of instinct are to be regarded as only one class of mental phenomena, we have here two kinds of mind, endowed with wholly different qualities, and acting in wholly different ways; one kind such that the being possessed of it neither knows nor intends what he is doing, and yet all the while does exactly as if he both knew and intended. Nay, in one case, the agent possessing this mind is manifestly able to act; in the other, he is as clearly incompetent in any way that we can conceive. If no being is here concerned except the apparent, and unconscious, and impotent agent, it is like matter gravitating to a centre which does not exist: and then, to make the thing still more incomprehensible, and the difference between matter as subject to general laws and this case the more extreme, both these kinds of mind are found in the same individual; for he sometimes uses, as it were, the one, sometimes the other; he sometimes acts knowingly and intentionally; sometimes blindly, as an instrument to do he knows not what, nor cares—as if we had a piece of matter, a lump of metal, for instance, which at one time was heavy, and at another flew about in the air.

A. There is certainly a material difference; and I should not much wonder if we were, sooner or later, driven by the extraordinary nature of the case to some new conclusion. These things have really not been sifted as they deserved. Men have rested satisfied with general and vague statements, and I suppose their attention has been too much engaged by the great curiosity of the facts connected with the subject to let them closely reason upon the theory. However, I must again recur to my supposition, and refuse to quit this position where we now stand until we have examined it more accurately. There are two kinds of mind, I will say. Then the Deity created two kinds originally. As he created two kinds of substance or existence, mind and matter, and as he endowed these with different qualities, so did he endow the two kinds of mind with different qualities. As he made matter solid and heavy, and made mind imperceptible to the senses, but endowed it with consciousness, so he gave the two kinds of mind different qualities—both of course must have consciousness, which I take to be the essence of all mind, at least we cannot conceive mind to exist without it—but one he made such that it could act rationally, knowing and intending all it did—the other such that it acted without knowing or intending. This hypothesis, you perceive, gets rid of the necessity of supposing a constant interposition of the Deity, unless in the sense in which He is said to interfere for the purpose of maintaining and executing the general laws which he originally framed for the whole universe.

B. I perceive no such thing. I do not think your supposition at all meets the fact, or removes the difficulty, or dispenses with the other inference. In one sense I may grant your assumption, namely, if you only meant that the Deity originally willed the animal should act in a certain way for a purpose which He foreordained, and which He yet concealed from the animal itself, though foreknown to Him, the Creator. But in the same way all rational acts and intentions may be said to have been foreknown and foreordained by the Creator, which indeed seems, at least in the case of an intelligent agent, only to mean that with the Deity there is no such thing as present and future, but all things are seen as present. But then this resolves itself into saying that the Deity originally designed and ordered the animal's acts; and that this is the same thing as if He actually superintended and did each act of the animal at the moment of action—which is the same thing with saying that the Deity constantly acts and not the animal, and that is the theory in question. But, in any other sense, to what does your objection, or the hypothesis put by you in order to escape the conclusion, amount? Only to this, that the Deity created the instinctive mind such that it acts without knowledge or intention, exactly as the rational mind acts with both the one and the other. Now the theory of course never meant to deny that the instinctive mind was created by the Deity, and endowed with certain qualities. Sir Isaac Newton expressly excludes the supposition of the Deity being the *anima mundi*, or the soul of any part of nature, and clearly never intended to represent Him, as Himself the soul of animals, but only as constantly guiding that soul. But the theory holds that the mind being endowed with certain qualities originally and at its creation, those qualities are summed up in this one, namely, to act, and to act *quasi* mind, but without knowledge or design, and yet to produce all the effects of both, and, moreover, that this constitutes the whole of the qualities of instinctive mind. This mind therefore was created such that it must always be the blind instrument in the Creator's hands; its knowledge and design, by the hypothesis, reside as it were out of itself and in some other intelligent being, that is, in the Deity, who is to supply at each instant, the knowledge and design wanting in the animal mind, or to know and intend for it—and whether the Deity performs this operation, exercises knowledge and intention, beforehand and once for all, or constantly and continually at all times, seems an immaterial distinction referable to the former head of the alternative. The question always recurs—Was a mind created of such a species that it could act *quasi* mind without knowing and intending? Is not that contrary to the nature and essence of mind? Nay, is it not a contradiction in terms? And is not your whole hypothesis of two kinds of mind grounded on a false position, which supposes a substratum to be endowed with various qualities, and then, in order to make two kinds of that substratum, confounds the qualities with the essence? For what is mind but that which thinks, knows, wills? If there be no knowledge, will, intention, at all, mind is not concerned in the operation, and we come to the Cartesian hypothesis, that the animal is a machine. Therefore knowledge and design there must be; and it must either exist in the animal mind or in some other mind which uses or employs the animal as an instrument. Can this higher mind do so beforehand, or otherwise than by constant operation, that is, constant exertion of itself?

A. Then are we not getting either to the Deity being the soul of the animal, or to the mind of the animal having none of the qualities constituting mind?

B. We may suppose the mind to be the mere power of giving voluntary motion to the limbs, and to consist of no other quality, unless it thinks and intends. Then the Deity may have suffered it to have these powers, and to use them in some things, and there His own intelligence does not interfere; but not to use such powers in other things, and there His intelligence does interfere.

A. There *is* knowledge and intention in the animal. The bee, for instance, knows it is carrying wax to a given place, and placing it in a given direction. So far as the thing is done, the agent knows, and wills, and intends what it is doing, and this in every possible case of instinctive action.

B. But the whole question arises, not upon what the bee knows and intends, *e.g.*, putting particles of wax in a place, but upon what she cannot possibly know anything about—the giving her work a peculiar form, most difficult to discover at first, most advantageous for a certain end, and still more difficult to follow and work by even when discovered. The question always is, who designs and knows these things unknown to the bee? And we cannot conceive the Deity acting thus originally through a future and non-existing animal; although we can easily enough imagine Him acting through an existing animal at the time. This is supposable on the theory of essential ubiquity, or indeed upon any theory of ubiquity, even virtual. It merely requires ubiquity—whether of essence, or of power—some ubiquity—which no one denies who believes in a Deity at all.

A. A child shall place together different lines and angles, or other parts of figures, so as to form certain diagrams. The figures he thus unwittingly makes have certain properties quite unknown to him. All he intends or knows is to put the parts together; the rest is consequential, arising from the necessary relations of number and figure: so in cases of physical or contingent truth: he may do, and mean to do, and know that he is doing, what will form a certain combination; but the laws of nature acting on that combination, produce, unknown to him, effects which he never intended, and knew nothing of; as if he mixed sulphuric acid and oil of turpentine, and there was an explosion; or an acid and an alkali, and there was a neutral salt and a crystallization.

B. This, when examined, we shall find either to be a case wholly different from the one in question, or to be only *idem per idem*, as lawyers say when they have a case put which is like enough to the one in hand, but just as difficult to resolve; so, in either way, the argument will remain unaffected. If the child plays with the things at random, and they happen to fall into a certain shape once, or it may be twice, that is certainly not the case of the bee, which regularly, and without ever failing, always makes the figure required; and, upon being obstructed in her operations, varies her means till she can again attain the particular form. If, on the other hand, the child places the things always accurately in the same way, then the case not only resembles the one in question, but becomes identical with it; all the arguments and all the difficulties apply; it is exactly *idem per idem.* So again, if the child does a certain thing with knowledge and design to do that and no more, leaving the rest to be done by some law of matter unknown to it—this is not the case of Instinct; for the bee does all that is done by the operation of mental agency; the wall, the hexagon, the rhomboid, are all made by the bee's living power; she does not place wax and leave it to fall into hexagonal forms, as we mix salts and leave them to crystallize into cubes or hexagonal prisms; she forms the figures herself, and when she has done her work nothing remains to be done further by any law of nature. But if the child makes a combination constantly and correctly, say some useful substance not to be made by accident or random working, then the case becomes the same, and the argument is not affected by it in any way.

A. You often complain of my obstinacy; which I call sometimes caution, and sometimes slowness, according as I may be in a self-complacent or a modest humour.

B. Then, as I do not remember ever to have seen you in the former state of mind, I am sure you must always call it slowness, which no one else ever called it; but I will call it caution, and ask what more it leads to?

A. To this—that I would again hanker after my doctrine of general laws, primarily impressed on matter and mind both. You argue, and argue justly, that the operations of matter and of mind are to be kept apart; you allow that the material operation is explicable by and referable to general laws; you allow, too, that whatever is wrought by the operation of mind, acting as such, is explicable by and referable to general laws of mind, originally imposed, *e.g.*, to desire what is agreeable to it by its general constitution; to reject what is by the same constitution disagreeable. But you say that we see, in the case of instinctive actions, operations for which desires and aversions will not account, and operations carried on as if by the most refined and correct reason, and yet without any material or physical interposition; that is, without any instrumentality whatever, as if a cast were made without a mould, or a print without a plate. From hence you say it is difficult to understand how there should not be here an intelligent being, as well as mere desires connected with the senses—a cause connected with the understanding. Now, hankering as before, I still ask —though perhaps, after our long argumentation, with somewhat diminished confidence — may not this be accounted for by supposing a general law adapting and adjusting all the proportions beforehand? May not the Deity have originally appointed the taste or desire of carrying caterpillars in the solitary wasp, for instance, exactly to the very number required to feed the worm after born, when, by the laws of matter, the egg shall have been hatched and the grub produced? So may not the bee form her hexagons and her rhomboids, in consequence of a gratification felt by a foreordained law of her nature, in following those lines and angles, and no other?

B. That this is barely conceivable I may perhaps admit. But it is wholly unlike any other operation of the senses and desires of which we have any knowledge. It means this, that each desire is so nicely adjusted as to produce in the animal the effects of reason and intention in man, or of reason and intention in the same animal when acting with design and knowledge, and not instinctively. The bird is to have a pleasure in bringing sticks or moss to a certain place, just at a given time, and putting them in one position

—the solitary wasp, in bringing, and only in bringing, for it never tastes, a certain number of caterpillars, and to have no gratification in bringing one more, but the strongest desire, because a sensible pleasure, in bringing the eleventh as much as the first—also no kind of gratification in carrying the eleventh to any other place than the same where all the other ten were put—also a like pleasure in forming the hole for them, without the least regard to the use she is to make of it, nay, ignorant beforehand of its being to have any use; and yet all the pleasure of carrying caterpillars is to consist in carrying them to that particular hole, and there is no gratification to be derived from carrying them to a place one hair'sbreadth on the right or the left. Still more—it means that the bee is to have such a gratification as proves irresistible, and occupies her whole life, in tracing certain lines and angles; and yet this strong desire is so far under control, even of reason, that on obstacles being interposed, other lines and angles are to be made, reason suspending the desire for the moment. So that the law originally imposed, and the quality impressed on the mind, was not one and inflexible, to do a certain act in all circumstances, viz., to follow the impulse of the desires implanted, and which form the animal's nature; but it was a law or order coupled with a condition, and, as it were, giving a discretionary power provisionally, or a power to be used in certain circumstances; it was as thus—a law or order to do a certain thing, to obey the impulse of the desire, unless certain events shall happen; and then and in that case to cease following the impulse of the desire, and to follow another guide, or rather to use a faculty, namely, reason, and act according as it should direct, allow, or recommend in the circumstances. Now, in the mere union of desires with reason, while the desires act blindly by impulse and the reason with discrimination, there is nothing at all inconsistent or incomprehensible;

it is the ordinary case of all mental operations. But the peculiarity of the case now supposed is that the desires act exactly like reason, producing the very same effects unknown to the agent which reason does with his knowledge. Are we not then calling different things by the same name, when we say that it is the influence of desires and appetites which makes the bee form her cell and the spider her web? Might not the same kind of argument be applied to the operations admitted on all hands to be those of reason, for example, the investigations of Newton or Lagrange? Might it not be said that they were influenced by an irresistible propensity, from deriving some gratification in drawing one line and using one divisor rather than another? But we know this not to be the fact. Why and how? Only from their statements and our own consciousness. But for this, the same argument might be used, and no one could refute it. So in the case of the animal we argue thus, because we cannot ask her and learn how she works. The impulse (it must all along be borne in mind) of which the argument speaks is a physical one, *i.e.*, the effect of some external object, or, which is the same thing, some operation of the animal's body, on her senses; it is a gratification of this specific kind which the explanation assumes—if not, it explains nothing. Then how little resemblance does any such gratification which we can form any idea of (leading the bee to her lines or angles, and the solitary wasp to her carriages and deposits) bear to what we know and feel to be the ordinary nature of physical gratification, and the desires connected with it.

A. This consideration has much weight—I mean the way you put the question as to the mathematicians. It seems to show that we have just the same right, in the case of the animal's instinct, to conclude in favour of design and reason, and an intelligent agent, and to conclude against its being animal impulse or the direct *operation* of the physical senses, as we should have, did we see the mathematicians at work, observe their process, and mark the result congruous with that process, before we spoke to them on the subject of how their working was conducted. Indeed it is remarkable that we are in point of fact just as much without the evidence which the thus inquiring of them would afford, as we are in the case of the animal; for who ever asked the question of either Newton or Lagrange, and yet who doubts that both worked their problems from knowledge with intelligence? The reason why we do not ask them is, that we have no kind of doubt in our minds; the view of the operation is enough for us. This is because we say to ourselves, "If I did so and so, I know it would be from knowing and meaning to do so and so, and not from any physical gratification." This inference we transfer to others, by saying, "Therefore I believe they act in like manner."

B. Certainly; and this, observe well, is the foundation of all our reasoning as to design. The only argument we ever have or can have in favour of any intelligent cause, from seeing the adaptation of means to ends, on surveying the works of nature, is, that, if we had done so and so, we should have had the design. All we see is the fact of an adaptation; the inference of a cause, or of a designing being, rests on the kind of reasoning you have just stated. So that in reality we have reached this important position, that our argument for the existence of a designing cause at all in the universe rests on no better, indeed no other foundation than our argument that instinctive action proves an interposition of the Deity at each moment.

A. I must further observe, however, that beside the great weight of this consideration as last presented, I feel the difficulty of the hypothesis of an original law generally imposed to be much aggravated by the consideration you adverted to at the same time, of a provisional and conditional law—a law to operate or not, according to circumstances, as if two implements had been given to the animal, Instinct and Reason; for I feel the very gratuitous nature of this assumption; and I know that there is not a greater proof of our reasoning being merely hypothetical on any question than when we find ourselves obliged to mould, refit, and modify our hypothesis, in order that we may adapt it to the new observations of fact.

B. But there remains a difficulty still more insuperable in your way, which you do not yet advert to. The supposition of a law, and a provisional or conditional law, is all along founded on the assumption of a person to obey it, to act instinctively, unless a certain thing happens, and then to use Reason till a certain other thing happens, and then to fall back upon Instinct again. What can be more gratuitous, not to say absurd? The supposition that the Instinct is to cease and the Reason to begin in a certain event, implies that the animal acting by Instinct all the while was reasonable and intelligent, else how could he know when to lay down his Instinct and take up his Reason? If I send a man to go straight on till he meets a messenger, or sees a finger-post, he is just as much a rational agent all the while he does not deviate from the way, as he is when, meeting the messenger or seeing the guide-post, he does deviate. So that the theory involves here this absurdity, that the instinctive action is all the while an intelligent and rational operation, contrary to the supposition. I can really imagine nothing more decisive or demonstrative than this—and I purposely kept it to the last.

A. Perhaps the end is not yet come; you have said nothing of the known errors or mistakes of instinct—and thus I reserve also my strongest argument to the last. I own that it was this consideration which, always meeting me, drove me to deny the Newtonian doctrine, and to find any or every other escape from it; for surely if the Deity is always acting, there can be no *mistake*—everything must be perfectly successful and quite certain. Yet how many cases of mistaken instinct do we see? Mules begotten; flies deceived by the smell of the stapelia to lay their eggs where they cannot breed the maggots, supposing the vegetable an animal substance putrefying; and many others. Now, if this was only the result of similar desires originally implanted, there is no difficulty; for the law would be to follow that smell, and this law is obeyed.

B. Now, I really think you have just yourself answered your strongest argument; for you admit there was that general law. Had it no design? Doubtless, and but one, to lead the animal towards its food, and the nest for its young—the two great objects of all nature, preserving the individual, and continuing the species. Yet here they fail in particular instances, and do neither. Then is not this a defect or imperfection in the general law, detracting, *pro tanto*, from its adaptation to work its undoubted purpose? The same Being gave the general law whom the Newtonian theory supposes to be the particular agent. Then is it not just as inconsistent with His perfections to believe He has made a faulty statute, as to suppose that He makes a mistake in particular cases? Can there be any difference at all here?

A. How do we get out of this in the general case?

B. You mean, how do we answer sceptical, or rather atheistical arguments, drawn from these supposed errors or imperfections? Only by saying, that as in the great majority of cases the design is perfect, and the wisdom complete, it is probable that further knowledge would remove all apparent anomalies, and reduce everything to order, and to a consistency with perfect wisdom and skill. In truth, we always assume design, even where we cannot trace it. The physiologist never supposes any part which he sees produced, as the spleen, to have no use; but rests satisfied that there is a purpose, though he has failed to discover it; and he hopes that it will hereafter be revealed to his inquiring eye. So when he finds apparent imperfection, he has a right—nay, it is sound logical reasoning—to suppose, that further knowledge would prove it to be perfect, as in the vast bulk of cases he has found perfection. The instances of erroneous or defective instinct are as mere nothing compared to those of true or perfect instinct.

A. We also approach here the argument on the Origin of Evil. There is something to be said, though perhaps not much, as to the irreverent nature of the supposition that the Deity acts, considering the meanness or impurity of some instinctive operations, and the trifling nature of others.

B. You may well say, not much in this; there is absolutely nothing at all. Our present argument only refers to physical, and not to moral considerations. Moral feelings or actions are of course not instinctive at all. There is no blame where there is no choice—no knowledge—no intention—no reason. Then, as to indifferent acts; there is nothing small, or mean, or impure in the Deity's eye. There is nothing in this more than is sometimes, without due consideration, urged against the doctrine of Essential Ubiquity. It all proceeds upon a forgetfulness that the Deity cares as much for one creature as another; all are alike proofs of his wisdom; all alike objects of his favour. So as to matter; there is nothing impure or disgusting, except in relation to our weak and imperfect senses, which are, for wise purposes, so formed as to delight in some things and to repudiate others. This is all relative, and relative to ourselves and our imperfect nature. To the Deity it can have no application. The structure and functions of the maggot, bred in the most filthy corruption that can disgust our senses, exhibits, even to the eye of the philosopher, how cumbered soever with the mortal coil, as marvellous a spectacle of Divine skill and benevolence as the sanguiferous or the nervous system of the human body, or the form of the *most lovely* and fragrant flower that blows.

A. I think the instinct of hunger has begun to operate upon my structure; whether stimulated by the operation of the gastric juice upon the coats of the stomach, or how otherwise, I do not stop to inquire. Nor do I apprehend that our good hostess's instinctive love of order and method would approve of our keeping dinner waiting.

B. Your own excellent mother was the pattern of that regularity, as of so many other admirable qualities; and the intercourse of society was in this, as in far more important particulars, greatly reformed by her example. Therefore let us adjourn our further discussion, of which not much remains, at least not much that is difficult, till to-morrow.

BOOK OR DIALOGUE III.

ANIMAL INTELLIGENCE.—(FACTS.)

A. IT must be confessed, that for a subject so extremely amusing as well as interesting in a higher view, Instinct has been giving us but little matter of entertainment. I question if any persons ever talked upon it for so many hours without almost a single anecdote, or illustration of any kind from the facts, which are inexhaustible in variety, and every hour present new matter of wonder. Indeed, those ordinarily known are full of interest; and we have been going on with, I think, two, the bee and the solitary wasp, never even casting a look over the rest of this boundless and variegated field.

B. Why truly so; and the reason is plain enough. We had a problem to solve, and we set ourselves to try our hand at it. We assumed that the whole facts resembled those few to which we applied our arguments, or from which we drew our inferences; and our choosing two was quite right and safe—indeed, one rather than two, for we have dwelt more on the solitary wasp than even the bee, because no question could ever be made in her case of training or traditionary instruction. I do not at all repent of having pursued this course; it has prevented digressions and distractions, which would have ensued, had we gone upon the facts at large. We should have been perplexed, sometimes by questions of evidence, sometimes by minute differences *of no importance* to the argument, sometimes by analogies only calculated to mislead. Our way has been to pitch upon a good example or two, which in some sort embody the subject, as far as matter of fact is concerned—an abstraction of Instinct, as it were, without immaterial particulars—and to confine our reasonings and our illustrations to that. However, there can be no sort of reason why we should not now reward ourselves with a little of the entertainment which, as you say, so amply belongs to this great subject.

A. The Instincts which we have been considering as our choice examples, especially that of the bee, are certainly the most wonderful of all the animal phenomena. But the cases where sagacity is shown, and which seem really quite inconsistent with the doctrine that denies brutes all rational faculties, are most frequently cited to raise men's wonder; and, as I take it, for this reason, that we set out with supposing the common animals to be wholly devoid of intelligence, and are astonished to find them sometimes acting as if they had it—while the operations of Instinct being in many brutes above what any degree of intellect can account for, we refer these to a totally different origin.

B. I quite agree with you. Perhaps one need not go much more now into examples of Instinct. None can exceed that of the bee, which has from the beginning of the creation been working, and all over the world working, in the same manner, upon the successful solution of a problem in the higher mathematics, which only the discovery of the differential calculus a century and a-half ago could enable any one to solve without great difficulty at all; and which a celebrated mathematician, who was devoted to the ancient geometry, though an adept also in modern analysis, when he solved, conceived that he had gained no small victory for that favourite science by showing that it could solve this question of maxima and minima.

A. Nevertheless, there are other wonders of a like kind, those which show Instinct to be as great in manufactures as the honeycomb proves it to to excel in architecture. The paper-making of the wasp is of this class. She makes a paper as excellent as any manufacturer at Maidstone; she has been for sixty centuries acquainted with what was only discovered by men between five and six centuries ago—for I think the question raised by Meerman confined the discovery to the years between 1270 and 1302, though afterwards a specimen was produced as early as 1243. Moreover, when some of the more recent improvements, as the lengthening and equalizing the fibres, are considered, it is found that the wasp was all along acquainted with these useful devices also.

B. I have observed, too, in examining her structures, that she makes two kinds of paper, white and brown, the former being fine cambric paper, and the two glued together by an excellent smooth and durable kind of cement. The white paper, I find, takes the ink as well as if it were sized.

A. When stories are told to excite wonder under the head of Instinct, they generally relate not to Instinct, but to the Reason or Intelligence which animals show. However, there are other wonders of Instinct beside those we have been adverting to. The uniformity of the operations of animals of the same species everywhere and at all times is remarkable; and the expertness they show from the first clearly proves that instruction and experience has nothing at all to do with the matter. Bring up a crow under a hen or under any other bird, it makes as exact a crow's nest as if it were born and bred in a rookery.

B. So Maraldi found that a bee an hour old flew off to the proper flowers, and returned in a little time with two pellets of farina, then supposed to be the material for making wax, now known to be used only in making bees breed, since the capital discovery of our John Hunter showed wax to be, like honey, a secretion of *the animal.* Nay, before birth too the animal works to an end, and with the same exact uniformity. The inimitable observations of the great Reaumur show that the chick, in order to break the egg-shell, moves round, chipping with its bill-scale till it has cut off a segment from the shell. It always moves from right to left; and it always cuts off the segment from the big end. There is no such thing as a party of what Gulliver calls "little-endians" in nature. All these singular Instincts, however, regular and uniform though they be, are, when circumstances require it, interfered with by the rational process of adapting the means to the end, and varying those means where the end cannot otherwise be attained. But Instinct is regular and steady in all ordinary circumstances.

A. The vast extent of the works performed by animals, especially by insects, is no less wonderful than their instinctive skill. This arises from their immense numbers, and the singular Instinct whereby they always work in concert when gregarious. What can be more astonishing than the work of the termites, or white ants, which in a night will undermine and eat out into hollow galleries a solid bed or table, leaving only the outside shell or rind, and soon will make that too disappear!

B. Or the ant-hills in tropical countries, twelve and fifteen feet high, as if men were to make a building the height of the Andes or Himalaya Mountains, when they are vain of having made the little pyramids? But let us go to instances of the other class—of Intelligence.

A. Had we better begin this new discussion by ascertaining whether or not the doctrine of a specific difference between man and the lower animals is well founded; or had we better begin with the facts?

B. I am upon the whole for beginning with the facts; and I should come at once, as we have just been speaking of concerted operations of Instinct, to the case of the beaver, which is, under the head of Intelligence, almost as wonderful as the proceedings of the bee and the ant are under that of Instinct.

A. But before quitting the bee, and the ant, and the wasp, let us just observe their rational acts. They are nearly as notable as their instinctive ones. The bee, upon being interrupted by Huber in her operations, shortened the length of her cells; diminished their diameter; gradually made them pass through a transition from one state to another, as if she was making the instinctive process subservient to the rational; and, in fine, adapted her building to the novel circumstances imposed upon her; making it, in relation to these, what it would have been in relation to the original circumstance if they had continued unaltered. It is found, too, that the ant, beside the wonderful works which she instinctively performs, has the cunning to keep aphides, which she nourishes for the sake of obtaining from them the honey-dew forming her favourite food, as men keep cows for their milk, or bees for their honey.

B. On this discovery of Huber some doubt has lately been thrown; and do not let us trouble ourselves with anything at all apocryphal when the great body of the text is so ample and so pure. But the expeditions of a predatory nature are by all admitted. They resemble some of the worst crimes of the human race; the ants undertake expeditions for the purpose of seizing and carrying off slaves, whom they afterwards hold in subjection to do their work—so that the least significant and the most important of all animals agree together in committing the greatest of crimes—slave-trading.

A. With this material difference, that the ant does not pharisaically pretend to religion and virtue, while we bring upon religion the shame of our crimes by our disgusting hypocrisy. But the wasp, too, shows no little sagacity as well as strength. Dr. Darwin relates an incident, to which he was an eye-witness, of a wasp having caught a fly almost of her own size; she cut off its head and tail, and tried to fly away with the body, but finding that, owing to a breeze then blowing, the *fly's wings* were an impediment to her own flight, and turned her round in the air, she came to the ground and cut off the fly's wings one after the other with her mouth. She then flew away with the body unmolested by the wind.*

B. I have myself observed many instances of similar fertility of resource in bees. But perhaps the old anecdote of the Jackdaw is as good as any—who, when he found his beak could not reach the water he wanted to drink, threw into the pitcher pebble after pebble till he raised the surface of the liquid to the level of his beak. Lord Bacon tells it of a Raven filling up the hollows in a tree where water had settled.

A. Or the Crows of whom Darwin speaks in the north of Ireland, who rise in the air with limpets and mussels, to let them fall on the rocks and break them, that they may come at the fish. It is said that animals never use tools, and Franklin has defined man a tool-making animal; but this is as nearly using tools as may be—at least, it shows the same fertility of resources, the using means towards an end.

B. It does a little more. It shows the highest reach of ingenuity, the using the simplest means to gain your end—the very peculiarity for which Franklin's own genius was so remarkable. He could make an experiment with less apparatus, and conduct his experimental inquiry to a discovery with more ordinary materials, than any other philosopher we ever saw. With an old key, a silk thread, some sealing-wax, and a sheet of paper, he discovered the identity of lightning and electricity. Here we are instituting a harmless comparison between the bird and the sage: but the crow's genius is said once to have come in collision with the head of a philosopher in a less agreeable manner, when, mistaking the bald skull of Anaxagoras for a rock, she let fall the oyster from such a height that it killed him.

A. But there certainly must be allowed to be even

* Zoonomia, Sec. xvi. 16.

nearer approaches to tool-making, or, at least, to the use of tools, among animals. There are many insects which use hollow places, and some which use hollow reeds or stalks for their habitations.

B. Indeed they do; and perhaps the most remarkable of all proofs of animal intelligence is to be found in the nymphæ of Water-Moths, which get into straws, and adjust the weight of their case so that it can always float—at least, Mr. Smellie says that when too heavy they add a piece of straw or wood, and when too light a bit of gravel.* If this be true, it is impossible to deny great intelligence to this insect.

A. Why should we doubt it? The crow in rising and letting the mussel fall shows as great knowledge of gravitation as the moth in this case.

B. But an old Monkey at Exeter Change, having lost its teeth, used, when nuts were given him, to take a stone in his paw and break them with it. This was a thing seen forty years ago by all who frequented Exeter Change, and Darwin relates it in his Zoonomia. But I must say that he would have shown himself to be more of a philosopher had he asked the showman how the monkey learned this expedient. It is very possible he may have been taught it, as apes have oftentimes been taught human habits. Buffon, the great adversary of brute intelligence, allows that he had known an Ape who dressed himself in clothes to which he had become habituated, and slept in a bed, pulling up the sheets and blankets to cover him before going to sleep; and he mentions another which sat at table, drank wine out of a glass, used a knife and fork, and wiped them on a table-napkin. All these things, of course, were the consequence of training, and showed no more sagacity than the feats of dancing-dogs and bears, or of the learned pig—unless it were proved that the ape on being taught these manipulations became sensible of

* *Transactions of Royal Society of Edinburgh*, vol. i., p. 42.

their convenience, and voluntarily, and by preference, practised them—a position which no experiments appear to support. Smellie, however, mentions a Cat which, being confined in a room, in order to get out and meet its mate of the other sex, learnt of itself to open the latch of a door; and I knew a Pony in the stable here, that used both to open the latch of the stable, and raise the lid of the corn-chest—things which must have been learnt by himself, from his own observation, for no one is likely to have taught them to him. Nay, it was only the other day that I observed one of the Horses taken in here to grass, in a field through which the avenue runs, open one of the wickets by pressing down the upright bar of the latch, and open it exactly as you or I do.

A. I have known, as most people living in the country have, similar instances, and especially in dogs.

B. But there is one instance of animals catching their prey in a way still more like the tool-making animal. I do not allude merely to the Spider's web, or to the Pelican's use of his large open pouch in fishing; but to an American bird, of which you find a curious account in the 'Philadelphia Transactions.'* It is called the *neun-tödter* by the Germans, as we should say the *nine-killer*, and is found to catch grasshoppers and spear them when dead upon twigs where the small birds come on which it feeds; for the grasshoppers themselves it never touches. These are left, generally about nine in number (from whence its name), the whole winter, and they attract the birds of which the animal in question makes its prey. This is really using one creature as a bait, in order thereby to decoy and catch another.

A. It is certainly a singular and curious instance, whether of Instinct or Intelligence. Are there not stories told of apes using a cat or some other animal—

* Vol. iv.

I should suppose rather anything than a cat—to get chesnuts out of the fire?—or what else is the origin of the phrase *cat's paw?*

B. Fable, I presume. Many fables have a real origin in fact: this, I suspect, has not. Monkeys, on the contrary, have been used by men to obtain fruit or cocoa-nuts, by pelting them, and their defending themselves with a fire of nuts.

A. That, however, is a plain instance of sagacity and imitation. They used missiles, as missiles were used against them. Some of our own belligerent measures of retaliation have not always been nearly so judiciously contrived.

B. No: we once, by way of retaliating on Napoleon, helped him; as if the monkeys had pelted themselves, instead of throwing at us. However, an unexceptionable authority, Captain Cook, or at least Captain King, in Cook's last voyage, has a singular instance of sagacity in the use of means, and almost weapons, in Bears. Here you have his account of their mode of hunting: "The wild deer (*barein*) are far too swift for those lumbering sportsmen; so the bear perceives them at a distance by the scent; and, as they herd in low grounds, when he approaches them, he gets upon the adjoining eminence, from whence he rolls down pieces of rock; nor does he quit his ambush, and pursue, until he finds that some have been maimed."*

A. Certainly, such a well-attested fact as this is very important, and worth a thousand stories of lions and jackals. But you spoke of coming at once to the Beaver, as the parallel to the Bee.

B. Certainly it is, and may be called, in respect of its works, the Bee of quadrupeds, or if you will, of Intelligent animals, holding among them as high a place as does the Bee among Instinctive creatures. Nevertheless, there may be some doubt raised how far Instinct

* Cook's Third Voyage, vol. iii., p. 306.

has a share in his operations. They are of great uniformity: all packs or companies of beavers, and at all times, build the same shaped structure, and resemble one another closely in matters which are arbitrary, and therefore cannot be considered as the result of experience or reflection—cannot be dictated by circumstances. This, however, opens a question of some difficulty, which, according to the plan we are pursuing, may be left to the end of our discussion, after we shall have gone through the facts. In considering the beaver, I think we shall do well to follow Buffon, as we did upon the ape, because he purposely rejected everything marvellous or doubtful in the accounts he had received from travellers, and these must have been numerous, for Canada was then a French colony. Those singular animals assemble in bodies of from two to four hundred, and choose a convenient station in the lake or the river, having regard to the slope of its banks and their woodiness, but also, no doubt, to the frequency of floods in the water. If it is a lake, or a river that varies little in its level, they build their huts without any further structure, but if the level changes much, they construct a dam or dyke, what we call a breakwater, extending eighty or a hundred feet across, and ten or twelve broad: they thus keep the water nearly of the same height, at least they thus always obtain a sufficient depth of water. They then work in concert on the wood, gnawing the trees and branches to suit their operations. A tree the thickness of a man's body they will soon bring down by gnawing round its base, but on one side merely, and they know so exactly the operation of gravity on it, that they make it fall always across the stream, so as to require no land-carriage. It must be observed, in passing, that if they do this the first time they have built, and without any previous experience of falling bodies, the operation must be taken as purely instinctive. They form their cabins so as to contain from fifteen to twenty-five or thirty animals;

each cabin has two doors, one to the land, and one to the water, in order that they may either go ashore, or bathe or swim, and sit in the water, which is part of their pleasure, or rather of their amphibious existence. They have in each cabin also a storehouse for placing the parts of the shoots on which they feed (for that they make provision against winter is quite certain), and room enough for accommodating their young when brought forth. The cabins are built on piles, so as to be out of the water; they are neatly plastered with cement, the animal's flat and scaly tail being used as a trowel in this operation. They are of sufficient strength to resist not only the stream and floods to which occasionally they may be exposed, but also severe storms of wind. The beavers choose to work with a kind of earth not soluble in water, and which they mix with clay. Such is the account of those very rational and intelligent proceedings which Buffon, sceptical beyond all men of stories respecting animal reason, sifted out of all he had heard, after rejecting everything that bore the appearance of exaggeration or fancy. He adds, that a single beaver which he had, showed, in its solitary and domestic state, no signs of sagacity or resources; but rather appeared to be a stupid animal. According to his strange theory, that animals are degenerating in mind, and losing their faculties as man improves (a notion derived from confounding their loss of dominion, power, and numbers, in a wild state, with their loss of intellect),* he considers the beaver as the "only subsisting monument of the ancient intelligence of brutes."

A. They say doubts have of late been cast upon the former accounts of the beaver. I am told, Hearne, one of the best North American travellers, is cited for this.

B. Here is what that excellent observer says upon the subject: you shall judge if he has in the least altered the case. The beavers select, he says, either

* Vol. iv., p. 73, and v., p. 21.

in small lakes or in rivers, spots where the water is of such depths as not to freeze to the bottom, preferring, however, running water, because this helps them to convey the timber they require. They begin by forming a dyke across with fascines, stones, and mud, but without piles buried in the ground; this dyke, whose only use is to give them a convenient level of water, is convex on the upper side fronting the stream; and it becomes solid and strong by repeated repairs, so that the branches sprout, and birds build in the hedge which it forms. Each hut contains commonly one or two, but sometimes four families; and sometimes each is separated from the others by a partition. The hut has a door opening on the water, and no connexion with the land. He then goes on to show how they cut down and build, wherein he differs from the common accounts only in saying that no piles are used in the construction. They work, he says, only by night, and each season they cover the buildings with a new coat of mud-plaster, as soon as the frost sets in. In summer they make excursions in the woods, choosing the trees they mean to make use of, and marking the position of new settlements, when their increase of numbers requires them to plant colonies. Their wood-cutting begins at the end of summer, and the building is carried on in autumn. They have also subterraneous retreats along the banks of the river or lake, to serve as a place of refuge when they may be attacked by the glutton. You perceive, then, that there is very little discrepancy between this account and Buffon's; indeed, there is one remarkable addition to the latter, if it can be relied upon, the precaution taken in summer to choose and to mark out the convenient stations where the new settlements are afterwards to be made.

A. There seems reason to suppose that other animals still preserve their sagacity and act in concert. No one can have observed a flock of pigeons without perceiving that they have sentinels posted to give the alarm. Indeed, wilder birds act in like manner. Fieldfares, when they are occupying a tree which you approach, remain steady and fearless until one at the extremity rises on her wings and gives a loud and very peculiar note of alarm, when they all get up and fly, except one who continues till you get near, as if she remained to see that there really was occasion for the movement, and to call them back if the alarm proved a false one. She too at length flies off repeating the alarm-note.

B. In the forests of Tartary and of South America, where the Wild Horse is gregarious, there are herds of five hundred or six hundred, which, being ill prepared for fighting, or indeed for any resistance, and knowing that their safety is in flight, when they sleep, appoint one in rotation who acts as sentinel, while the rest are asleep. If a man approaches, the sentinel walks towards him as if to reconnoitre or see whether he may be deterred from coming near—if the man continues, he neighs aloud and in a peculiar tone, which rouses the herd and all gallop away, the sentinel bringing up the rear. Nothing can be more judicious or rational than this arrangement, simple as it is. So a horse, belonging to a smuggler at Dover, used to be laden with run spirits and sent on the road unattended to reach the rendezvous. When he descried a soldier he would jump off the highway and hide himself in a ditch, and when discovered would fight for his load. The cunning of Foxes is proverbial; but I know not if it was ever more remarkably displayed than in the Duke of Beaufort's country; where Reynard, being hard pressed, disappeared suddenly, and was, after strict search, found immersed in a water-pool up to the very snout, by which he held a willow-bough hanging over the pond. The cunning of a Dog, which Serjeant Wilde tells me of, as known to him, is at least equal. He used to be tied up as a precaution against hunting sheep. At night he slipped his head out of the collar, and returning before dawn, put on the collar again, in order to conceal his nocturnal excursion. Nobody has more familiarity with various animals (beside his great knowledge of his own species) than my excellent, learned, and ingenious friend, the Serjeant; and he possesses many curious ones himself. His anecdote of a drover's dog is striking, as he gave it me, when we happened, near this place, to meet a drove. The man had brought seventeen out of twenty oxen from a field, leaving the remaining three there mixed with another herd. He then said to the dog "Go, fetch them;" and he went and singled out those very three. The Serjeant's brother, however, a highly respectable man, lately Sheriff of London, has a dog that distinguishes Saturday night, from the practice of tying him up for the Sunday, which he dislikes. He will escape on Saturday night and return on Monday morning. The Serjeant himself had a gander which was at a distance from the goose, and hearing her make an extraordinary noise, ran back and put his head into the cage—then brought back all the goslings one by one and put them into it with the mother, whose separation from her brood had occasioned her clamour. He then returned to the place whence her cries had called him. I must however add, that I often have conversed with Scotch shepherds coming up from the Border country to our great fairs, and have found them deny many of the stories of the miraculous feats of sheep-dogs. Alfred Montgomery and I, the other day, cross-questioned a Roxburghshire shepherd with this result.

A. Many of the feats which we are now ascribing to intellectual faculties may be instinctive operations. How shall we distinguish?

B. The rule seems simple. Where the act is done in ordinary and natural circumstances, it may be called instinctive or not, according as it is what our reason could, in the like circumstances, enable us to perform or not, and according as the animal is in a situation which enables him to act knowingly or not. Thus a bee's cell is made by a creature untaught; a solitary wasp provides food for an offspring it never can see, and knows nothing of. We set these things down to Instinct. If horses, fearing danger, appoint a sentinel, it may be Instinct certainly, but there is here nothing to exclude Intelligence, for they do a thing which they may well do by design, and so differ from the bee; they are aware of the object in view, and mean to attain it, and so differ from the wasp. But these remarks apply to acts done in ordinary circumstances, and which I admit may or may not be instinctive. Another class is clearly rather to be called rational. I mean where the means are varied, adapted, and adjusted to a varying object, or where the animal acts in artificial circumstances in any way. For example, the horse opening a stable-door, the cat a room-door, the daw filling a pitcher with stones. So there is a singular story told by Dupont de Nemours in Autun's 'Animaux Célèbres,' and which he says he witnessed himself. A Swallow had slipped its foot into the noose of a cord attached to a spout in the Collége des Quatre Nations at Paris, and by endeavouring to escape had drawn the knot tight. Its strength being exhausted in vain attempts to fly, it uttered piteous cries, which assembled a vast flock of other swallows from the large basin between the Tuileries and Pont Neuf. They seemed to crowd and consult together for a little while, and then one of them darted at the string and struck at it with his beak as he flew past; and others following in quick succession did the same, striking at the same part, till after continuing this combined operation for half an hour, they succeeded in severing the cord and freeing their companion. They all continued flocking and hovering till night; only, instead of the tumult and agitation in which they had been at their first assembling, they were chattering as if without any anxiety at all, but conscious of having succeeded.

A. The means taken to escape from danger, and to provide for security, are certainly often of this description, the danger being often of a kind purely accidental and solitary, and the operation of the animal varying in different and new circumstances. Some birds wholly change their mode of building to avoid snakes, hanging their nests to the end of branches, and making the exit in the bottom, in places where those reptiles abound.

B. So too the Ants in Siam make no nests on the ground, as with us, but on trees, that country being much subject to inundations. But you find this change of habits in animals, upon circumstances changing, pretty general. The Dogs which the Spaniards left in the island of Juan Fernandez were found to have lost the habit of barking, when Juan and D'Ulloa visited that famous spot in the course of their journey in South America. Possibly they found that barking warned their prey, and enabled it to escape. But Dogs in Guinea howl and do not bark, and when European dogs are taken there they lose their bark in three or four generations. This fact, then, is somewhat equivocal.

A. The docility of some animals may, however, as it seems to me, be strictly ranged within the class of facts we are speaking of. Although children, as well as animals, learn through fear and kindness, both operating (and fear alone would suffice), yet it is an act of Intelligence to follow the dictates of both feelings: it implies this process of reasoning,—" If I do so and so, I shall have such a punishment or such a reward." Now the degree to which animals are teachable is wonderful. All Singing-Birds probably learn their whole notes.

B. Yes, Daines Barrington has demonstrated this by numerous experiments* on various birds; the young

* Phil. Trans., 1776.

untaught birds, being placed in the nests of different species of birds, always had the song of those it nestled with; and we all know how a Piping Bullfinch can be taught almost any tune. They seem to have no notion of harmony or melody. I recollect a Green Linnet, which I had when a boy, or rather a mongrel between that and a goldfinch, being placed in a kitchen, and leaving its own fine and sweet notes, to take to an imitation, and a very good and exceedingly discordant one, of a jack which, being ill-constructed, generally squeaked as if it wanted oiling.

A. Dogs show the greatest talents in learning. The feats of pointers, but still more of shepherds' dogs, after making all the deductions you have mentioned, are astonishing. It almost seems as if the shepherd could communicate, by sign or by speech, his meaning, when he desires to have a particular thing done. But assuredly the dog takes his precautions exactly as he ought, to prevent the sheep from scattering, and to bring back runaways. Indeed, Greyhounds and other dogs of chace, as well as Pointers backing one another, show the adaptation of, and variation in, the means used towards an end.

B. Retrievers exceed all other dogs in this respect. There was one died here a year or two ago that could be left to watch game, till the keeper went to a given place, and she would then join him after he had ranged the field; nay, could be sent to a spot where game had been left, and where she had not been before. Indeed, she did many other things which I have hardly courage to relate.

A. How were her pups? I have always found such extraordinary faculties hereditary.

B. My worthy, intelligent, and lamented friend, T. A. Knight (so long President of the Horticultural Society), has proved very clearly that the faculties of animals are hereditary to such a point as this. He shows that even *their acquired* faculties — the expertness they gain by teaching—descends in the race. His paper is exceedingly curious. But I think we need hardly go so far as to his minute details for proof of the fact. It is found that where man has not been, no animals are wild and run away from his approach. When Bougainville went to the Falkland Islands (or, as the French call them the Malouines), he found himself and his men immediately surrounded by all kinds of beasts and birds, the latter settling on their shoulders. No navigators had ever been there before. Lord Monboddo says that the same thing had been related to him by navigators.* It seems clear, then, that the running away from man, which seems natural to all wild animals in or bordering upon inhabited countries, is an acquired propensity, transmitted to the descendants of those whose experience first taught it them as necessary for their safety.

A. Have you Knight's paper here? I know the accuracy of his observation to equal his great ingenuity.

B. To that I too can bear my testimony. Here is his principal paper, read lately before the Royal Society. It is given as the result of his observations and experiments, made for a period of sixty years; it is therefore most justly entitled to great respect. He chiefly dwells on the case of Springing Spaniels, and among other instances gives this, which is indeed very remarkable. He found the young and untaught ones as skilful as the old ones, not only in finding and raising the woodcocks, but in knowing the exact degree of frost which will drive those birds to springs and rills of unfrozen water. He gives the instance, too, of a young retriever, bred from a clever and thoroughly-taught parent, which, being taken out at ten months old, with hardly any instruction at all, behaved as well and knowingly as the best-taught spaniel, in rushing into the water for game that was shot, when pointed out to

* Origin of Language, b. ii., ch. 2.

it, however small, bringing it, and depositing it, and then going again, and when none remained, seeking the sportsman and keeping by him. He imported some Norwegian ponies, mares, and had a breed from them. It was found that the produce "had no mouth," as the trainers say; and it was impossible to give it them; but they were otherwise perfectly docile. Now, in Norway, draught horses, as I know, having travelled there and driven them, are all trained to go by the voice, and have no mouth.—Again, he observed that they could not be kept between hedges, but walked deliberately through them—there being, he supposes, none in the country from which their dams came.

A. Does he speak of any other animal?

B. Yes, he mentions his observation on woodcocks, which he could remember having been far less wild half a century ago; for on its first arrival in autumn, it was tame, and chuckled about if disturbed, making but a very short flight, whereas now, and for many years past, it is very wild, running in silence and flying far. He gives an instance of sagacity in a Dog, unconnected with hereditary intelligence. He one day had gone out with his gun and a servant, but no dog. Seeing a cock, he sent the servant, who brought this spaniel. A month afterwards he again sent for the same dog from the same place. The servant was bringing him, when at twenty yards from the house the spaniel left him, and ran away to the spot, though it was above a mile distant. This he often repeated, and always with the same result; as if the animal knew what he was wanted for. Leonard Edmunds tells me of a dog (a Newfoundland spaniel) of Mr. Morritt's, at Rokeby, which has been known to take the shorter road to where he knew he was wanted, and leave the servant or keeper to go round about. You yourself told me of a dog that met you sporting by a short cut unknown to you.

A. The manner in which animals can find their way is very extraordinary. But though, in many cases, it may be through close observation, and observation the clearer and better remembered because, like the Indian woodsmen, they have so few ideas; yet, in other cases, it seems an Instinct very difficult to conceive in its workings. In truth, if the stories told be true, I question if any instance we have yet examined of Instinct be so truly unaccountable on any principles of intelligence. I have known of dogs sent to a distance, and coming home immediately, though taken in the dark.

B. That might be from smell or track, but stories are also told of dogs and cats taken in hampers, and finding their way back speedily. L. Edmunds had one that was carried from Ambleside to three miles on the other side of Burton, a distance of twenty-seven miles, in a close hamper, by a coach; and it found its way back next morning. Dr. Beattie's account of a dog which was carried in a basket thirty miles' distance, through a country he never had seen, and returned home in a week, is less singular than this, even if it were as well authenticated. Dr. Hancock, in his excellent work on Instinct, which, however, contains fully as much upon the peculiar tenets of the Society of Friends as upon our subject, relates the story of a Dog being conveyed from Scotland to London by sea, and finding his way back; of a Sheep returning from Yorkshire to Annandale, a distance of at least eighty miles; and of another Sheep returning from Perthshire to the neighbourhood of Edinburgh. Kirby and Spence, too, in their 'Introduction to Entomology,' state, on the authority of a captain in the Navy, a strange anecdote of an Ass taken from Gibraltar to Cape de Gat on board of ship, and finding its way immediately back through Spain to the garrison, a distance of two hundred miles of very difficult country. The ass had swam on shore when the ship was stranded. This fact seems to be well authenticated, for all the names are given, and the dates.

A. There is no end of such facts, and many of them seem sufficiently vouched. The 'Letters on Instinct,' mention a cat which had been taken to the West Indies, and on the ship returning to the Port of London she found her way through the city to Brompton, whence she had been brought.

B. That is a work I have often wished to see, and never been able to get. Dr. Hancock quotes it for one of the most remarkable proofs of sagacity and resource in the Goat, and this operation has been, it seems, observed more than once. When two Goats meet on a ledge bordering upon a precipice, and find there is no room either to pass each other, or to return, after a pause, as if for reflection, one crouches down and the other walks gently over his back, when each continues his perilous journey along the narrow path.

A. In 'Rees's Cyclopædia' a story is given as well vouched, of a cat that had been brought up in amity with a bird, and being one day observed to seize suddenly hold of the latter, which happened to be perched out of its cage, on examining it was found that a stray cat had got into the room, and that this alarming step was a manœuvre to save the bird till the intruder should depart. But what do you make of carrier-pigeons? The facts are perhaps not well ascertained; there being a good deal of mystery and other quackery about the training of them.

B. I desired one of the trainers (they are Spitalfield weavers generally) to come, that I might examine him about his art, but he has never been with me. I have read and considered a report made to me on the subject. It is said the bird begins his flight by making circles, which increase more and more in diameter as he rises; and that he thus pilots himself towards his ground. But still this indicates an extraordinary power of observation; for they come from Brussels to London and return. Nay, they have been known to fly from the Rhine to Paris. Serjeant Wilde took *pigeons* of the Rock kind to Hounslow, and they flew back to Guildford Street in an hour. They were taken in a bag, and could see or smell nothing by the way. On being let loose, they made two or three wide circles, and then flew straight to their dovecot. The Serjeant also knew of a cat which a shopkeeper's apprentice in Fore Street had been desired to hang, and found he could not. He then took it in a bag to Blackfriars Bridge and threw it into the river—the cat was at home in Fore Street as soon as the apprentice. He might have made a circuit, but certainly the cat returned in an hour or two. The grocer's name was Gardner—the distance is certainly above a mile, and through the most crowded part of London. The case of bees is referable to Instinct clearly. Honey-finders in America trace their nests by catching two bees, carrying them to a distance, and letting them fly. Each takes a straight line towards the nest or hive, and by noting these two lines, and finding where they intersect each other, the hive is found. Now the bee is known to have a very confined sphere of vision, from the extremely convex form of her eye. She is supposed only to see a yard or so before her.

A. I fancy we must pass over the subject of migration for a like reason. It seems still involved in much obscurity and doubt, though I take for granted that no one now yields to Daines Barrington's theory, which denies it altogether.

B. Clearly no one; the facts are quite indisputable as far as negativing that goes; and indeed his reasonings are so full of prejudice, or preconceived opinion, and his suppositions for disposing of the facts so strained, that his argument never could have had much weight. One fact seems also not to be disputed, and is referable to Instinct alone. I mean the agitation which, without any cause, comes on upon a bird of any of the migratory classes at the appointed season of migration. It is, in all probability, connected with the sexual impulses.

A. The communication with each other, which animals have by sounds or signs, can, I think, hardly be doubted.

B. The observations of Huber clearly show that ants have a kind of language by means of their feelers or antennæ; and every day's experience seems to show this in other animals.

A. Some believe that they have a notion of what men are saying, and no doubt very strange and lucky guesses have sometimes been made, one of which I wrote you an account of. I had it from a most accurate and literal person, and it tends to prove that his shooting dogs had found out his intention of going into Nottinghamshire the day after. However, it is perfectly clear that these things are referable to minute and exact observation of things which escape us in the greater multitude of our ideas and concerns. All this, however, only illustrates the more how well animals can profit by experience, and draw correct inferences from things observed by them.

B. Among other instances referable plainly to intelligence must be ranked the devices which one animal is known to fall upon for benefiting by another's operations. The ant enslaving workers is the most curious instance certainly. But the cuckoo laying in other birds' nests, and leaving her progeny to be brought up by them is another. Nor can this be set down wholly to the score of Instinct; for there are abundant proofs of her also building when she cannot find a nest, and then she lays in her own, and hatches and rears her brood. This curious and important fact, long disbelieved by vulgar prejudice, was known to that great observer Aristotle, who says she sometimes builds among rocks and on heights.* Darwin confirms this by the observations of two intelligent friends whom he cites.† The man-of-war bird is a still more singular

* *Lib.* vi., c. 1. † Zoonomia, vol. xvi., p. 13.

instance of contrivance, for though its food is fish, it has not such a form as to be fit for catching any, and therefore it lives piratically on the prey made by other fishing birds; hence the name we have given it.

A. Only think of our never having all this while said a word, or more than a word, of either the Fox or the Elephant, proverbially the two wisest of animals. Of the former's cunning every day shows instances; but that the elephant should be left to take care of a child unable to walk, and should let it crawl as far as his own chain, and then gently lift it with his trunk and replace it in safety, seems really an extraordinary effect of both intelligence and care, and shows that fine animal's gentle nature, of which so many anecdotes are told by travellers in the East.

B. The amiable qualities of brutes are not quite within the scope of our discussion, unless indeed in so far as whatever things are lovely may also be said to betoken wisdom, or at least reflection. The natural love of their offspring I should hardly cite in proof of this, because it seems rather an instinctive feeling. But the attachments formed between animals of different classes, a cat and a horse, a dog and a man, and often between two elderly birds, may be cited as interesting. One of these friends has been known to be unable to survive the other. I have heard this of two old parrots, upon the best authority.

A. We have said nothing of fishes, or of any marine animals.

B. Why, of these our knowledge is necessarily very limited. That they have remarkable Instincts, some of them resembling those of land animals, is certain. The Sepia, or cuttle-fish, ejecting a black or dark-brown fluid to facilitate his escape, resembles the stratagem of some beasts emitting an intolerable effluvia in the face of their pursuers. The Whale, when attacked by the Sword-fish, diving to such a depth that his enemy cannot sustain the pressure of the water, is another well-known example of defensive action. I used to observe with interest the wary cunning of the old Carp in the ponds here: there was no decoying them with bait, which the younger and less experienced fish took at once. So little have men formerly undervalued the faculties of fishes, that Plutarch wrote an ingenious treatise in the form of a dialogue, on the question whether land or water animals have the most understanding.

A. How does he treat this odd question?

B. Here is his book; and certainly as far as the first portion of the subject goes, where the merits of land animals are concerned, he sails before the wind. To his first remark I willingly subscribe, that those hold the most stupid doctrine upon the subject (*οἱ αβελτερως λεγοντες*) who say that animals do not really fear, rejoice, remember, rage, &c., but only do something like fearing, rejoicing, &c. (*ὡσανεῖ φοβεισθαι*, &c.); and he asks what such reasoners would think were it also contended that animals do not see, but make as if they saw; nor hear, but make as if they heard; nor roar, but make as if they roared; and, finally, do not live, but only did something like living. He then relates a great variety of facts respecting the sagacity of animals, some of them evidently fabulous (as the love of a dragon for a young woman), and some, as the account of the ant laying in grain, now proved to be erroneous; but he gives others worthy of attending to. Thus, the contrivance of African crows, who, when the water was scarce, threw pebbles into deep cracks of the earth, so as to bring the fluid up towards the surface, and within their reach — the similar cunning of a dog on board of a vessel—the like device fallen upon by elephants to rescue one that had fallen into a pit—the astuteness of the fox, used by the Thracians as a kind of guide in crossing a river frozen over, to find out whether the ice is thick enough, which the animal does by stopping and listening to hear *if the* water is running near the surface—the judicious mode of flight in which cranes and other birds of passage marshal themselves, forming a wedge-like body, with the strongest birds at the front angle or point. But when he comes to the other side of the question, and is to state the case for the fishes, we find a great falling off both in his facts and in his evidence. Beside telling very absurd stories about crocodiles in Egypt obeying the call of the priests and submitting to their influence, he dwells upon the Sepia, whose escape in a black cloud of his own making he compares to the tactics of Homer's gods; upon the cunning shown by fishes in gnawing lines to escape with the hook; nay, upon a story he tells of their helping one another to escape when caught, which is plainly groundless; upon the Torpedo, or electrical eel, giving shocks, which is clearly a mere physical quality, and no more indicates reason than the shark using his teeth; upon shoals of fishes, like flocks of birds, forming themselves into wedges when they move from one sea to another, which is certainly true; upon the dolphin loving music, which is purely fabulous, as well as the feats of wisdom and philanthropy that he ascribes to this fish (*μονος γαρ ἀνϑρωπον ασπαζεται καϑο ἀνϑρωπος εστι*); finally, upon all the fables to be found in the poets respecting this fish. After reciting one of these, by way of proving his case in favour of marine animals, he innocently enough says that although he had promised to relate no fables, he now finds himself, he knows not how, in the company of Cæranus and Ulysses, and so he brings his notable argument to a close.

A. How does he ultimately decide the question propounded?

B. With a verse of Sophocles, intimating that both sides have gained some advantage towards a common purpose; but the victory is given to neither, the umpire pronouncing that both the arguments combined overthrow the doctrine of those who deny Reason and Intelligence to animals generally.

A. There are no modern books which fully discuss this subject systematically, either as regards Instinct or Intelligence. One is exceedingly disappointed in consulting our best writers, whether metaphysicians or naturalists, with this view; and the omission is the less to be excused because there are great opportunities of observing and comparing: this branch of knowledge is eminently suited to inductive reasoning; we live as it were among the facts, and have not only constant facilities for making our experiments, but are in some sort under a constant necessity of doing so.

B. Truly it is as you say. I have often felt this disappointment and this disapprobation. The works of metaphysical writers contain a few scattered suggestions, or dogmas, and with these they leave the subject. Naturalists, who could throw so much light upon it, confine themselves chiefly to the structure and functions of the organs, and leave the mental part of the subject out of view. Yet a physiologist, who also applied himself to this latter branch of the inquiry, would be the person best qualified to grapple with its difficulties and to throw light upon it. Therefore I learnt with extreme satisfaction that an able and learned professor of Natural History had given a course of lectures upon it at Paris, and was still more gratified to find that he soon afterwards published them. I speak of M. Virey's work; those two thick volumes lying there contain above a thousand pages on the Habits and Instinct of Animals; and to raise my expectation still higher, it professes by its title to deal in facts—for it is called 'Histoire des Mœurs et de l'Instinct des Animaux.'

A. Well; I suppose you rushed upon it to slake your thirst?

B. As a traveller upon a delicious and copious spring, and found it a picture; or upon a luscious-looking large peach, and found my mouth filled with chalk. I have *had these* volumes here these two years, and I can barely now say I have been able to get through them. They are throughout not only written in the very worst style of French sentimental declamation, but they avoid all precision, all details, all facts, as something grovelling, common-place, and unimportant. The constant object is not to find out or illustrate some truth, to describe or arrange some phenomenon, but to say something pretty, far-fetched, and figurative. And all this with an arrangement of the classes of animals so methodical, that on looking at the contents, and finding they proceed regularly from the structure of the globe and the general qualities of its different products, to mammalia, then to birds, reptiles, fishes, and so downwards through the invertebrated animals, ending with zoophytes and mollusca, you naturally expect under each head to have what the title promises, a History of the Habits and Instincts; and find nothing of the kind from beginning to end, but only trope after trope, one piece of finery after another, nothing but vague declamation long drawn out, an endless succession of the most frivolous sentimentality. Truly such a work, from so learned a naturalist, one who could so well have instructed and entertained us, had he but chosen to be plain and didactic, instead of being brilliant and rhetorical, where all eloquence and ornament are absolutely misplaced, is no small offence in the literary world.

A. I'll assure you our French neighbours are not the only sinners in this particular. I have been somewhat mortified of late years at perceiving a tendency to fine writing and declamation among our own men of science, and I ascribe it, in some degree, to the more general diffusion of scientific knowledge, which naturally introduces the more popular style of composition. Our Society of Useful Knowledge has no sins of this sort on its conscience, because we correct with unsparing severity all we publish; but you may perceive the tendency of popular explication to run in this bad direction, from the kind of matter that is often submitted to us for revision. I am sure I sometimes draw my pen through half a page of fine writing at a time.

B. I will engage for it you do inexorably whenever you find such outrages. My experience is precisely the same; and I am just as severe on those parts, evidently the prime favourites of the learned and very able writers. But we originally set out with firmly resolving to be most rigorous in matters of taste, being aware, as you say, of the tendencies of popular writers. In truth, however, that vile florid style darkens instead of illustrating; and while we never can write too clearly to the people, we never can write too simply, if our design be to write plainly and intelligibly. But though our Society is free from having any of this blame, I cannot quite acquit of all blame the meetings, however useful and praiseworthy in other respects, of an association which brings crowds of hundreds and thousands together, to hear mathematicians and chemists making declamatory speeches. I must say that those assemblages offer some violence to Science, at least they somewhat lower her by showing her cultivators trying a trade they no more can, or even ought to excel in, than poets in solving questions of fluxions. It is since these meetings, otherwise useful and excellent, rose into eloquence, that I have seen a mathematical discussion, by a very able and learned man, in two consecutive pages of which I reckoned up above twenty metaphors —all tending to darken the subject—to say nothing of poetical quotations without any mercy. Formerly declamations were reckoned so little an accomplishment of scientific men, that when Bishop Horsley filled our Royal Society with a factious controversy, the ministerial side, Sir Joseph Bank's party, had to send for assistance—and where think you they went for an orator?

A. I suppose to some Nisi Prius advocate.

B. Guess again.—No!—So humble were their views of oratory that they went to the other side of the hall, *as the lawyers say*, and got for their champion, Mr.

Anguish, who was Accountant-General, a Chancery man, and had perhaps made as few speeches as any one in that Court. But in the work which I have referred to, and even in those scientific meetings, there is at least much that is highly valuable, much good grain, and the trash may be rejected as chaff—whereas, in this piece of French declamation all is chaff, and hardly a grain can be gleaned out of the light and worthless matter.

A. Can you find nothing by sifting and bolting it? I generally find something even in the worst books.

B. I will not say that these heavy volumes of light matter contain absolutely nothing; but wondrous little assuredly they have to reward the pains of searching. What can be more hateful than a man of science unable to speak of granivorous animals without terming them Pythagoreans and Gymnosophists; calling the crying baboon of South America a wild Demosthenes, the lion a generous prince, the jackal a courtier; describing the nightingale as appealing to Heaven against the robber of her nest, and the crocodiles as the "sad orphans of nature," because hatched in the sand; nay, carrying his ridiculous fancies into actual practice, seriously explaining the mild temper of one animal by the sweetness of its humours, and the ferocity of another by the acrid juices of its system—all a pure fiction in fact, as well as a gross absurdity in theory! Then mark the consistency of a philosopher—a consistency worthy of the veriest mob. He denounces, as the most atrocious of men, the experimenter on a living dog or rabbit, Fontana, or Majendie, I suppose, and afterwards speaks with the utmost composure of dividing a bee in two, in order to examine her honey-bag. Of the bee, indeed, he seems very moderately informed. He speaks of Aristarchus having devoted his life to the study of this insect, instead of Aristomachus; assumes to be true the notion long exploded of honey being collected from flowers, instead of a secretion in the stomach; will not believe that wax, too, is a secretion, though he refers unconsciously to Huber's experiment of obtaining it from bees feeding upon sugar and water; and, to set off his modern natural history with a little false classical lore, must needs call the cells "their citadel, or the palladium of their republic."

A. Bad enough in all conscience. But now give us the grain or two of wheat in all this bushel of chaff.

B. First, and this makes it more provoking, the author writes clearly and admirably when he chooses to leave off declaiming. There is a long note upon vertebrated and invertebrated animals, showing with much clearness and precision that in the former, which have a cerebral and nervous system, Intelligence prevails; in the latter, Instinct. He maintains the specific difference of Instinct and Reason or Intelligence with great force and clearness; indeed, there seems nothing to find fault with in his statements here, except that he places the seat of Intelligence in the cerebral nervous system, and of Instinct in the ganglionic, and thus is forced to deny Intelligence altogether to insects, whereas we have seen that Huber's observations plainly show the bee to have the capacity of varying its means in accomplishing the end in view when the circumstances vary; and this surely cannot be distinguished from Intelligence. Also he discusses, with perfect strictness of reasoning, the hypothesis of a very celebrated naturalist, no less than M. Lamarck, and, I must say, refutes very satisfactorily the theory of my most learned and worthy colleague, for whom we all must feel the most profound respect. He had been induced to suppose that Instinct results from the habits originally acquired by animals adapted to the circumstances in which they found themselves placed at the beginning of the creation, and that these habits occasioned an adaptation of their structure to particular operations, as well as a constant capacity and desire to perform them. Now, my only objection to M. Virey's refutation of this theory, which is merely the exploded doctrine of appetencies in a new form, is, that it requires no such elaborate answer to overthrow it. For what do we see in all nature which in the least entitles us to suppose any animal at any period to have had the power of altering his bodily structure, creating one part and altering another according to his wants? Besides, if animals, at their first creation, had so much power and so much intelligence as this theory supposes, why should this all cease and leave them only possessed of blind Instincts now? The reasoning, however, of M. Virey is sound, and does much credit to his acuteness.

A. But have you found, in his volumes, no facts; nothing to place among the phenomena which we are collecting previous to resuming our discussion respecting the faculties of brutes?

B. Very little; and that so wrapped up in declamation, and so disfigured with figures (if I may thus speak), that there is no small difficulty in seizing hold of it. What he says of the architecture of squirrels, marmots, rats, and some other rodents, is new to me. I had only been aware of the beaver, among this tribe, as remarkable for ingenuity. But it seems these others excel all animals in digging subterranean dwellings; they make compartments or chambers, which they line with clay, and cover with a roof from the weather; in some of these chambers they stow vegetables, which they previously dry in the sun; others they use for the reception of their young; in others they sleep. He brings together some curious instances of swift and long-sustained flights of birds. Thus the smallest bird, he says, can fly several leagues in an hour; the hawk goes commonly at the rate of a league in four minutes, or above forty miles an hour. A falcon of Henry II. was flown from Fontainebleau, and found, by its ring, at Malta next day. One, sent from the Canaries to Andalusia, returned to Teneriffe in sixteen hours, a distance of nearly seven hundred miles, which it must have gone at the average rate of about forty-three miles an hour. Gulls go seven hundred miles out to sea and return daily; and Frigate-birds have been found at twelve hundred miles from any land. Upon their migration he states, as a known fact, that Cranes go and return at the same date, without the least regard to the state of the weather, which shows, no doubt, if true, a most peculiar instinct; but these, and, indeed, all facts which we find stated by a writer so addicted to painting and colouring, must be received with a degree of suspicion, for which no one but M. Virey is to be blamed. The accounts, however, of the swiftness of birds, I can well credit, from an experiment which I made when travelling on a railway. While going at the rate of thirty miles an hour, I let fly a bee; it made its circles as usual, and surrounded us easily. Now, if there was no current of air or draught to bear it along, this indicated a rate of ninety miles an hour; and even allowing for a current, the swiftness must have been great. I should, however, wish to repeat this experiment before being quite sure of so great a swiftness in so small an insect.

A. Have you given all your gleanings from this work?

B. I should, perhaps, add these two. We find in it a curious passage from an old Spanish author of the seventeenth century, giving a quaint and lively account of the sagacity of the beggars' dogs at Rome; and we also find the titles of some German works on the faculties of brutes, which are truly curious, and show how great a degree of attention that laborious people have paid to the subject, but, at the same time, betray not a little of the characteristic boldness and enthusiasm of their speculations.

A. I conclude you have never seen more than these titles in this book?

B. Never; and I really should wish to see the works *themselves.* One is 'Mayer de peccatis et pœnis Brutorum,' 1686, in quarto. Another, in 1725, 'Hermanson de peccatis Brutorum;' this, however, is printed at Upsal. A third is 'Schrœder de Simulacris virtutum in Brutis Animantibus,' 1691; and a fourth, 'Schrœder de Brutorum Religione,' 1702. Then, it appears that one Drechsler wrote, in 1672, a 'Dissertation on the Speech of Animals,' and Meyer and Martin, not to be outdone, followed this up a few years after, the one with a 'Treatise on the Logic of Animals,' and another with one 'De Animalium Syllogismo.'

A. Does the Spaniard give any curious particulars of dogs?

B. Not perhaps any that surpass what we have been stating from facts known among ourselves. But his account is diverting enough. "The blind man's dog," says he, "will take him to the places where he may best hope to get his alms, and bring him thither through the crowd by the shortest way and the safest; nay, he will take him out of the city some miles to the great church of St. Paul, as you go to Ostia. When in the town he cometh to a place where several ways meet, and with the sharpness of ear that the blind have, guided by some sound of a fountain, he gives the string a jerk by either hand, straightway will the poor dog turn and guide him to the very church where he knows his master would beg. In the street, too, knoweth he the charitably-disposed houses that be therein, and will lead thither the beggar-man, who, stopping at one, saith his pater-noster; then down lieth the dog till he hear the last word of the beadsman, when straight he riseth and away to another house. I have seen myself, to my great joy, mingled with admiration, when a piece of money was thrown down from some window, the dog would run and pick it up and fetch it to the master's hat; nor, when bread is flung down, will he touch it be he ever so hungry, but bring it to his master, and wait till he may have his share given him. A friend of mine was wont to come to my dwelling with a great mastiff, which he left by the door on entering; but he, seeing that his master had entered after drawing the string of the bell, would needs do likewise, and so made those within open the door, as though some one should have rung thereat."

A. Upon my word, you have been amusing yourself with making the old Castilian speak in old English.—But now, I think, we may be said to have gone at sufficient length into the facts, and to have gathered together a collection large enough for our purposes of speculation—nor have we perhaps much more to do with this in that way. For can any one rationally doubt that they evince in these brutes some faculties at least approaching in kind to our own—nay, and to such of our own as we are wont to prize the most, and to be the proudest of? No blind impulse of a mechanical kind, no mere instinct, or feeling, or operative principle, apart from knowledge, experience, learning, even intention,—can surely account for the things we have just been considering as done by animals—and one example, and an ordinary one, is as good as a thousand. The cat opening a door from observing men do so before it; or the bird, from its own observation of the effect produced by solid bodies, sunk in water, raising the water by throwing in pebbles; or letting mussels fall to break the shells—these things surely argue a thinking and a reasoning process.

B. There seems little doubt of this; however, we may perhaps adjourn the further discussion, as we no longer require to be among our books, but may take our walk out in the sun, which is far from disagreeably hot to-day.

A. I have no kind of objection, and will meet you on the Terrace as soon as I have written my letters.

BOOK OR DIALOGUE IV.

ANIMAL INTELLIGENCE.—(Theory.)

We accordingly finished our letters, and prepared to go out and walk about in the sunny exposure, which a north-west wind made agreeable, as in the north it often does, even at this season—"calceis et vestimentis sumptis, placitum est ut in aprico maxime patente loco conveniremus:"*—where, as we walked about, he began in continuation of his last remark.

A. I know not why so much unwillingness should be shown by some excellent philosophers to allow intelligent faculties, and a share of reason, to the lower animals, as if our own superiority was not quite sufficiently established, to leave all question of jealousy out of view, by the immeasurably higher place which we occupy in the scale of being, even should we admit the difference to be in degree rather than in kind; because when the difference of degree becomes so vast, there is hardly any more chance of encroachment or confusion, hardly any more likeness or comparison, than if the difference were radical and in kind. Some writers, as D. Stewart, really seem to treat the question as one of an exciting nature, and almost to regard the purity of religious belief as involved in the controversy. How is this, and why should it be?

B. It is possible that the origin of the feelings shown by those good and able men, resembles that of Descartes' absurd theory, of brutes being like machines,

* "Having taken our boots and greatcoats, we chose to meet in an open and sunny exposure."—*Cic. de Repub.*, lib. i., cap. 12.

which, as far as he holds it, he avows to have proceeded from the notion that unless they are so, their souls would be immortal. But another reason may be assigned. The sceptical, or free-thinking, philosophers always lowered human nature as much as possible. They regarded it as something gained to their arguments against religious belief, if they could show the difference to be slighter than is supposed between men and brutes; and that there is a chain of being from the plant, nay, almost from inorganic matter, up to man. They seem to have had a confused idea that this helped them even to account for the constitution of the universe, "without the hypothesis of a Deity," as Laplace is said to have termed it when Napoleon questioned him on the remarkable omission in the 'Mécanique Céleste.' Thus much is certain in point of fact, that those philosophers, and especially the French school, were fond of lowering the human intellect by raising that of animals; and while the priests were lavish of their admission that our moral nature is utterly corrupt but claimed for our intellectual capacity to be only a little lower than the angels, the society of the Encyclopédie, and the coterie of Baron d'Holbach were fond of levelling the intellectual distinction between immortal and confessedly mortal beings, though they denied the moral depravity of their race with perhaps no very strict regard either to the evidence of their consciousness or of their observation. It thus appears that this theory of a difference in kind is found in company with that of scepticism, just as some other theories are usually coupled with it also; for example, the selfish system,—philosophical necessity,—expediency,—materialism,—all of which are held by Hume, Voltaire, Helvetius, Diderot, and other free-thinkers; yet all of which are also held by some as determined believers as any that are to be found in any church. Priestley, for instance, held all these doctrines, and Paley all but *the last*. Hume's opinion on the reason of brutes cannot be doubted from some accidental remarks interspersed in his writings. Helvetius, a materialist and sceptic both, has explicitly stated that if the arm of man had chanced to terminate in the foot of a horse, he would still have been found wandering about as the tenant of the woods.* The company in which the opinion has been found has thus greatly disinclined pious men towards it. Professor Robinson, in his attacks on the French school, is nowhere more severe upon them than where he impeaches them of endeavouring to lower the dignity of human nature,† and undoubtedly such attempts may be made in a manner to hurt the interests both of religion and of morals.

A. Has not Lord Monboddo given great offence of the same kind, and in the same quarters?

B. Possibly he has; although from his station as a judge, and a man of most loyal political opinions, and also from his being an orthodox believer, at least as far as professions go, he has been less blamed than the rest. He was an admirable Grecian, such as in modern times Scotland has very rarely produced; and there is an infinite deal of ingenuity and subtlety as well as learning in his writings, with a constant display of most correct taste in judging of the ancient controversies. But his theory has subjected him to great ridicule, not so much from his holding that there is a gradation in the whole scale of beings, and that the mental faculties of man are found in the minds of brutes, as from his denying any specific difference even in body; and holding that originally men were fashioned like monkeys, and lived like them wild and savage.

A. I could much more readily understand this doctrine giving offence and scandal as heterodox, than the other; for it seems not very easily reconcileable either to our religion or indeed to almost any other received among civilized nations.

* De l'Esprit. † Proofs of a Conspiracy.

B. I consider it a thing just as little supported by the facts, as it is repugnant to all known systems of theology. But my objection to it is really not founded upon its tendency to lower human nature. On the contrary, I doubt if it does not rather exalt our faculties beyond all the ordinary doctrines, and draw a broader line of distinction between us and the lower animals than that which it was intended to efface. For surely if we have not only by our intelligence made the great progress from a rude to a refined state—from the New Zealander to Laplace, and Newton, and Lagrange—but have also, by the help of the same faculties, made the progress from the state of monkeys and baboons, while all other animals are the same from one generation to another, and have made not a single step for sixty centuries, and never have attempted in a single instance to store up for after-times the experience of a former age, our faculties must needs be immeasurably superior to theirs. In short, the only question is as to the nature of the difference.

A. I can well suppose a difference merely in degree sufficient to explain any diversity of condition or result. We have only to compare individual men together to perceive this. It is admitted that reason, nay, that the power of forming abstract ideas, as well as drawing inferences from premises, is possessed by persons whom yet you shall in vain attempt to teach the simplest mathematical demonstration. Then their faculties only differ in degree from those by which Pascal learnt geometry without a master or a book, and Newton discovered Fluxions, and Lagrange and Euler the Calculus of Variations. It may truly be said, that there is no difference in kind which could make a greater diversity in the result.

B. It may indeed be truly so said; but it may also be added, that there is not a greater difference, call it in kind or in degree, between the person whose obtuseness you have supposed, and a sagacious retriever, or a clever ape, than between the great mathematicians you have named, and that same person. Locke, whose calmness of understanding was equal to his sagacity, and never allowed his judgment to be warped by prejudice, or carried away by fancy and feelings, seems to have held this opinion, and indeed to have allowed some reason to animals. "There are some brutes," he observes, "that seem to have as much knowlege and reason as some that are called men;" and he goes on to say that there is such a connexion between the animal and the vegetable kingdom, as makes the difference scarcely perceptible between the lowest of the one and the highest of the other.

A. You quoted Addison's paper upon Instinct yesterday, in proof of his taking the Newtonian view of the subject. What does he say as to the Reason, and generally the Intelligent faculties, of animals?

B. He is, as you are aware, no very great reasoner; insomuch, indeed, that I have known persons made converts to Deism, or rather from Christianity, by reading his most feeble treatise on the Evidences. One man of great virtue, learning, and ability confessed as much to me. Accordingly, he is very wavering and inconsistent on this subject also, and encounters it with prejudice. At one place he says, reason cannot be the cause of brutes acting as they do; and then, after seeming to deny it, he only adds a kind of admission that they have reason: "for," says he, "were animals endued with it to as great a degree as man," &c. And again, in the same paper, he seems to deny it altogether. "One would wonder to hear," he says, "sceptical men disputing for the reason of animals, and telling us it is only our pride and prejudices that will not allow them the use of that faculty." This is exactly the notion to which I was a little while ago imputing the unwillingness of so many reasoners to allow brutes their fair share of intelligence. You see Addison considers it the natural course of a sceptic; yet surely Locke was as firm a believer as himself, and certainly a far more reflecting and intelligent one.

A. Perhaps we had as well consider, before going into the question, by what kind of logic the argument is to be conducted, by what sort of evidence we are to try the cause.

B. I presume there can be no doubt here. We must examine it according to the rules of inductive science. The facts are before us. Some we gather from observation—those relating to animals; some, as those respecting the nature of the human mind, we ascertain by our own consciousness, or at least chiefly by that, though in some sort also by observing other men's conduct, and communicating with them; but having no means of communicating with animals, we are reduced to our observation merely; and then we naturally draw the inference that, because the same things done by ourselves would be known by us to be done from certain mental powers, therefore we ascribe those powers to the animals. This conclusion as to ourselves is certain, because we know and feel it to be so by our own consciousness. With respect to animals it is not nearly so certain, because we cannot either enter into their minds, as we do into our own, or communicate with them, as we do with our fellow-men. Nevertheless, by varying our observations on them, by making experiments on their faculties, by placing them in new and arbitrary combinations of circumstances, we can reduce the chances of error to a very small amount, and render our inferences as highly probable as most of the propositions of contingent truth are.

A. It is not, however, necessary that we should now go into an investigation of the nature of the human faculties. Our researches are in their nature comparative only.

B. Certainly; and therefore, agreeing with you, I would begin by laying down this position, that all we *have to do* is to grant or to deny the existence of certain mental faculties, and to ascertain the meaning of the terms which we employ in expressing these. Whatever those faculties may be in us, all we are now to consider is, whether or not the brutes have the same, or in any degree.

A. I think it quite right and really for our safety, in conducting the inquiry, to lay down a second preliminary principle or caution, namely, that we have no right to argue from the mere effects produced by certain endowments, or by any given combination or modification of these. Thus, when we see what has been achieved by man, and contemplate the extraordinary monuments raised by his industry, his activity, and his intelligence, and the power which he has acquired over the operations of nature, and of all other animals, profiting so largely by both, and when we compare this with the feeble state of those animals, their having no accumulation of either knowledge or possessions, and gained nothing upon man or by man, we are drawing a contrast which really proves nothing; because it is just as easily accounted for by supposing the two classes extremely different in degree, as by assuming that they differ in the kind of their faculties. Thus to take a common instance, and one which Adam Smith himself gives as marking a great difference between us and the brutes, they have no appearance of barter; but if barter arises from comparing ideas together, and forming a conclusion from the premises, and if, from other facts, animals appear to possess that power, there being no positive barter only shows that their judgment or reasoning faculties are weaker than ours, or that for some other reason, it is immaterial to the argument what, they have not acquired that particular result of the reasoning faculty.

B. I entirely agree in this general position, holding that the neglect of it has been one main cause of the errors into which philosophers have fallen on this question; I must, however, doubt the correctness of the position, that the brutes are wholly ignorant of barter.

No one, as Smith says, ever saw one dog barter a bone with another. But many of the operations of both dogs and horses in dividing their labour, and of insects, as ants, in helping each other, seem referable to a principle not to be easily distinguished from barter. The division of labour is clearly to be observed among them. Of course I do not mean that comminute division by which bees work together, and in which they incalculably excel ourselves; for that we have classed as instinctive and unintentional, and therefore it cannot enter into our present argument. But horses plainly help one another in drawing, and take different parts of the work; so do dogs in the chace. However, to leave no doubt about it, and allowing beavers to act instinctively, the wild horses sleeping and watching by turns is a clear and unequivocal instance of the division of labour. But I admit your position—that if anything which is the result of a faculty, proved already to be one of the animal mind, is not possessed by them, this is no argument against their having that faculty. It may lead us to be the more cautious in examining the proofs by which their possession of the faculty is established: but that is all. Indeed, such distinctions are taken upon no more philosophical ground than he would have for his classification who should make two divisions of metals or of water, one the solid, and another the fluid, accordingly as they had different temperatures.

A. I hold it to be a part of the same preliminary position, that if brutes are shown to possess any given simple faculties, their not having the power of doing things only to be accomplished by combinations of these simple powers, does not impeach the proposition, already established, of their having those simple powers. For it would only show that they have not the combination, though they may have the separate powers. Does any other proposition occur to you as convenient to be laid down in the outset?

B. I should say this, which is perhaps rather a corollary from the last, that we must carefully distinguish between simple and composite faculties, as they are called. Indeed, I deny the accuracy of this form of speech, and I believe it tends much to error in metaphysical speculations. No system of psychology, ancient or modern, sanctions it; neither those of Hartley, Priestley, Berkeley, nor that of Reid and Stewart and Brown, although I think it has been much encouraged by the speculations of these last, and their separate treatment of our mental powers under distinct heads, how necessary soever this was for the elucidation of the subject. The mind being one, and entire, and invariable, without parts or composition, acts always as one being. It recollects, praises, judges, abstracts, imagines; and when you say that it exercises a compound, or complex, or composite faculty, as for example, the imagination, you only mean that it first exerts one faculty, then another, and then a third. We never should call the process by which chemists bleach vegetable substances a composite operation, because they first make oxymuriatic gas, then mix lime with water, then, by agitation of the water exposed to the gas, cause lime to combine, and then expose the vegetable fibre to this compound liquor; we say that these are so many successive operations performed, and not one complex operation. And so imagination is not one compound faculty, nor is imagining one complex operation of the mind. But that mind in succession remembers, abstracts, judges or compares ideas, and reasons or compares judgments—and the whole four successive operations form imagination; to which you may add the further operation of taste, which, rejecting one and selecting other results of imagination, produces the fruits of refined or purified fancy; if indeed this taste itself be anything but a sound exercise of judgment—a judgment refined by experience, that is, by constant attention to what is pleasing, and what disagreeable. The rapidity with which all these separate operations are performed by the mind, neither prevents them from being in succession and separately performed, nor at all shows the mind to have composition or parts. Giving names to certain combinations, or rather successions of operations, and not to others, may be correct; but it must be admitted is somewhat capricious. We talk of imagination as if it were one operation, though it is many; and yet we give no separate name to several other successions as rapid of our mental operations. So as to our moral feelings. We speak of conscience as one; yet it is, as Smith describes it, a succession (he says a compound) of several, among which pity for the party injured, and fear of the consequences to ourselves, are the chief. Yet we give no name to the reflection on past enjoyments, which is as quick a succession of several emotions,—namely, recollection, comparison of the present, and sorrowing for the contrast. However, as regards our present purpose, the simplest part of the proposition is, that any given simple faculty or single operation of the mind being found to be possessed by animals, the circumstance of their not possessing the compound exclusively, or several combined, or a successive operation of different faculties, is no proof against their having the simple ones. Thus, if they have no fancy, it is no proof that they have no memory or judgment; because they may have these without having abstraction, which is one of the faculties that go to make the imaginative process. But it is also no proof of their being without abstraction, and all the other simple or single faculties; for it only proves that they have not the power of using these faculties together, or rather in quick succession, and for the same joint purpose. And should they have the simple or single, without having the compound faculties or processes, this would again argue no specific difference, but rather a diversity of degree.

A. I think these preliminary positions not only have *cleared* the ground for us, but helped us a good way on our journey. There appears hardly much more to reason about now. The subject has been a good deal enveloped in mist and smoke, from confusion of ideas, and from prejudice and high feeling. These being blown away, it seems pretty clear what the structure is that we are to examine.

B. Before going to the brute faculties, let us just cast a glance over the faculties which have been enumerated as belonging to ourselves, and see if they should not be a little simplified—Sensation, Perception, Consciousness, Memory, Abstraction, Imagination, Judgment, Reasoning, to which have been added Taste and the Moral Sense; and Mr. Stewart thinks these not enough, adding among others, the power of connecting general or abstract signs with the things signified. Now suppose we admit the correctness of calling a state of mind in which it is purely passive an active power or faculty, as Sensation, which is merely the effect produced upon the mind by the operation of the senses, and involves nothing like an exertion of the mind itself, any more than receiving a hurt or a gratification passively is any exertion of the body, although the operation whereby that reaches the mind may be termed bodily exertion; then it will follow, and not otherwise, that Sensation is a faculty. But Perception is no doubt an active exertion of the mind. *Memory* differs from Recollection as Sensation does from Perception. The state of mind in which one idea calls up another, or a present state of mind influenced by a past state, is Memory. The exertion by which the mind voluntarily induces the present state from the past, is Recollection. The one is the *sensation*, the other the *perception* of the past, as sensation and perception are of the present.

A. Is not Perception an inference from Sensation? I have the sensation of solidity or of smell, and I perceive either the solid, resisting body, and the odorous body, or I perceive the solid or odorous quality, that is, I infer a being from the sensation, or I infer a quality; the former seems a simple inference, the latter an inference coupled with an abstraction.

B. I do not incline altogether to this opinion; but at any rate it will not apply to Memory and Recollection; for Recollection is not an inference from Memory; it is an effort by which the mind throws itself into the state into which it might have been brought by the former ideas recurring of themselves. In Perception we do not voluntarily throw the mind into the state of Sensation; we draw an inference from that sensation according to your theory. But I think it pretty clear that there is something between the sensation and the inference—the simple apprehension and the conclusion drawn. The latter is clearly an inference that an external being exists which created the sensation and the perception. But I think there is also a perception upon the sensation, and which cannot certainly exist without it. However, be this as it may, to our present purpose it makes no difference, except as far as there can be no doubt of the mind being in a much more passive state in the two conditions of feeling and remembering than in the other two of recollecting and perceiving.

A. Then of Imagination we have already disposed. It consists of the successive, though rapidly succeeding operations of other faculties whereby we create or combine new ideas that had no previous existence, abstracting the qualities of one object to clothe another with them. But Abstraction we may allow to be a simple operation and one of the most important. What do you make of two that I do not remember you to have named, Attention and Conception?

B. I omitted them purposely. I can see really nothing in Attention but the degree in which certain other faculties operate. It is only the intensity with which I perceive. Possibly there may be some good from considering it as the difference between Perception and Sensation; in the latter case the mind passively receives the impression of the senses; in the former it fixes itself steadily upon those impressions, so as to feel them by a voluntary effort more acutely. As for Conception, which used formerly to be called Simple Apprehension, it is only the forming ideas of objects neither presented by the senses nor by the imagination; and I am unable to separate it from Memory and from Abstraction—from memory as far as it deals with former ideas, from abstraction as far as it deals with quality apart from the objects remembered or imagined.

A. Then Judgment being the comparison of ideas, and Reasoning the comparison of judgments, that is, of the ideas arising from the former comparison, may be set down as one faculty—that of Comparing—and I conclude you make quick work with Taste and the Moral Sense, of which the one gives us preferences among objects of mental gratification, and the other among objects of moral approbation?

B. They are both evidently exercises of the judging and reasoning powers—say the comparing powers, according to two standards,—the one the sense of beauty or fitness, of what is pleasing or agreeable; the other, the sense of what is just and right. But whether this last sense is natural or acquired, and how acquired, is a question that has long divided philosophers, and which will very certainly never be determined. Nor is it more easy to determine the other, which is quite a kindred one, how it is that our taste is formed, and whether it be natural or acquired. All that we can say on this subject is, to remark the little practical importance which belongs to either question, and to state that, as far as our present discussion is concerned, the only faculty involved in either the one or the other is that by which we compare different ideas.

A. Our enumeration then of mental faculties seems to resolve into Perception, active or passive; Memory, active or passive; Consciousness, Abstraction, and Comparison; then how do we place animals as to the first?

B. Clearly no animal, nothing having life, can be conceived to exist, without Passive Perception at all events, and hardly any without Active Perception also. Consciousness too seems a necessary quality of every mind; it is the knowing one's own existence; so Memory of the passive kind must exist in every mind; without Consciousness and Memory no animal could know its own personal identity; and no acts could be done by it upon the supposition of that identity. With respect to Active Memory and Conception, if this is to be held a separate faculty, it is implied in Comparison, or in judgment and reasoning; so that our inquiries come to be confined within sufficiently narrow limits. Do the lower animals possess Abstraction and Comparison? I will at once begin with Abstraction, because it is the power most generally denied to brutes; and this arises, as I conceive, from an ill-grounded notion of its nature, and from a supposition that it is a faculty of a far more refined nature, subservient to operations of a much more difficult kind, than the truth will warrant us in affirming. The truth appears to be, that there are, if not two kinds of Abstraction, an active and a passive, yet certainly some degrees of Abstraction so easy and even unavoidable, that we can hardly conceive almost any mind incapable of forming them. But on the other hand, the very highest and most difficultly attained reach of human thought is connected with Abstraction. Observing this, philosophers have passed all under one name, and because the brutes could not conduct algebraical investigations or metaphysical reasonings, have denied them all power whatever of forming abstract ideas.

A. To a certain degree this is no doubt true. The abstraction by which we reason upon m and n or x as *only* numbers; deal with x the unknown quantity, multiplying it and speaking of m times x, or dividing it and speaking of one n^{th} part of x, is no doubt a high and refined reach of thought; but so is the forming to ourselves an idea of abstract qualities; indeed I know not if, when we reason about m and x, we do more than mechanically deal with the letters; whereas in reasoning of colour or smell as abstracted from the rose with which we always have seen them conjoined, and forming to ourselves the idea of something in the abstract which we have only ever seen in the concrete, —of some ideal existence of which in actual existence we have never known anything, nor can know,—we really appear to go a step further. Now do you maintain that Abstraction is ever otherwise than a difficult and painful operation?

B. First of all be pleased to observe that many philosophers altogether deny, even to man, the power of forming abstract ideas. The dispute of the *Nominalists* and *Realists*, so well ridiculed by Swift, or rather by Arbuthnot in Scriblerus, is as old as metaphysical inquiries, under one name or another. They consider it impossible for us really to form these abstractions, and hold that we only are using words and not dealing with ideas, just as you seem to think we do in algebraical language. Mr. Stewart is among those who conceive that we think in language. My opinion, if against such venerable authority I may venture to hold one, is different. I think we have ideas independent of language, and I do not see how otherwise a person born deaf and dumb and blind can have ideas at all; which I know they have, because I carefully examined the one of whom Mr. Stewart has given so interesting an account. Indeed he has recorded the experiment of the musical snuff-box which I then made upon this unhappy but singular boy. But next I am to show you that abstraction independent of algebra, or metaphysical reasoning altogether, is neither difficult nor painful. Without Abstraction we cannot classify in any way, or make any approach to classification. Now I venture to say that no human being, be he ever so stupid, is without some power of classification, nay, that he is constantly exercising it with great care, and almost unavoidably, and acting upon the inferences to which it leads. He can tell a man from a horse. How? By attending to those things in which they differ. But he can also tell a stone from both, and he knows that the stone is different from both. How? By attending to those things in which the two animals agree, and to those things in which they differ from the stone. So every person having accurate eyes and the use of speech can call a sheet of paper and a patch of snow both white; a piece of hot iron and of hot brick both hot. He has therefore the idea in his mind of colour and of heat in these several cases, independent of other qualities, that is, abstracted from other qualities; he classifies the white bodies together, independent of their differences; the hot bodies, independent of theirs; and he contrasts the white metal with the white snow, because they differ in temperature, without regarding their agreeing together in colour. All this is Abstraction, and all this is quite level to the meanest capacity of men. But is it not also level to brute intellect? Unquestionably all animals know their mates and their own kind. A dog knows his master, knows that he is not a dog, and that he differs from other men. In these very ordinary operations we see the animal mind at one time passing over certain resemblances and fixing on differences; at another time disregarding differences and fixing only on resemblances. Nay, go lower in the scale. A bull is enraged by a red colour, be the form of the body what you please. A fish is caught by means of a light, be it of any size or any form.

A. These things which you last mention are mere sensations. The red light or the flame impresses the retina and affects the animal's sensorium, his brain—irritating the quadruped and attracting the fish.

B. What then? Other sensations pass to his mind through his senses at the same time. He has the sensation of form as well as colour; yet he passes this entirely over, and only considers the colour. However, take those cases in which animals are attracted to certain places. They are hungry and go to a certain field to eat, without the least regard to its position or its shape; because it agrees with other fields in bearing the food which the beast is in quest of. Flies approach the light because they believe it to be the open air where they wish to go. So the bird never throws stones into a river or puddle to raise the water; but it does throw them into the ewer. It abstracts water from the thing containing it; and could not reason upon the effects of the operation without a process of Abstraction. Indeed, upon the footing on which you would put it, I know not that all our own abstract ideas may not in the end be resolved into sensations and their immediate consequences. I know of no evidence that you have of our abstract ideas being formed in any other way, except on our consciousness, and our continual communication of ideas and experience through speech. In the case of the brute we have all the same phenomena, and, excluding the operation of blind Instinct, we are forced to the like conclusions.

A. I think we may go a step farther; have not animals some kind of language? At all events they understand ours. A horse knows the encouraging or chiding sound of voice and whip, and moves or stops accordingly. Whoever uses the sound, and in whatever key or loudness, the horse acts alike. But they seem also to have some knowledge of conventional signs. If I am to teach a dog or a pig to do certain things on a given signal, the process I take to be this. I connect his obedience with reward, his disobedience with punishment. But this only gives him the motive to obey, the fear of disobeying. It in no way can give him the means of connecting the act with the sign. Now, connecting the two together, whatever be the manner in which the sign is made, is Abstraction; but it is more, it is the very kind of Abstraction in which all language has its origin—the connecting the sign with the thing signified; for the sign is purely arbitrary in this case as much as in human language.

B. May we not add that they have some conventional signs among themselves? How else are we to explain their calls? The cock grouse calls the hen; the male the female of many animals. The pigeon and the fieldfare and the crow make signals; and the wild horse is a clear case of signals. All this implies not only Abstraction, but that very kind of Abstraction which gives us our language. It is in fact a language which they possess, though simple and limited in its range.

A. As to the power of comparing, what is commonly called Reason, *par excellence*, comprising Judgment and Reasoning, this needs not detain us very long. The facts here are not well liable to dispute. There is no possibility of explaining the many cases which we began by going over without allowing this power. They all prove it in some degree. Several of them show it to exist in a very considerable degree. The acts of some birds and monkeys cannot be accounted for by Instinct; for they are the result of experience; and they are performed with a perfect knowledge of the end in view; they are directed peculiarly to that end; they vary according as the circumstances in which they are performed alter, and the alteration made is always so contrived as to suit the variation in the circumstances. Some of these acts show more sagacity, according to Mr. Locke's observation, than is possessed by many men. The existence of a comparing and contriving power is therefore plain enough. And on the whole I conceive that a rational mind cannot be denied to the animals, however inferior in degree their faculties may be to our own.

B. That inferiority is manifestly the cause why they have made so little progress, or rather have hardly made any at all. Some little is proved by such facts as Mr. Knight has collected, but they are only exceptions to the rule which has doomed them to a stationary existence. This difference, however, is merely the result of the inferior degree of their mental powers, as well as the different construction of their bodily powers. The want of fingers endowed with a nice sense of touch is an obstruction to the progress of all, or almost all, the lower animals. The elephant's trunk is no doubt a partial exception, and accordingly his sagacity is greater than that of almost any other beast. The monkey would have a better chance of learning the nature of external objects if his thumb were not on the same side of his hand with his fingers, whereby he cannot handle and measure objects as we do, whose chief knowledge of size and form is derived from the goniometer of the finger and thumb, the moveable angle which their motion and position give us. Insects work with infinite nicety by means of their antennæ; when these are removed they cease to work at all, as Huber clearly proved. Clearly this different external conformation, together with their inferior degree of reason, is sufficient to account for brutes having been stationary, and for their being subdued to our use, as the Deity intended they should, when He appointed this difference. To argue from the complex effect of all the faculties, bodily and mental, in giving different progress or power to our race and to theirs, and to infer from this difference that there is an essential and specific diversity in our mental structure, nay that they have not one single faculty the same with ours in kind, is highly unphilosophical. It is indeed contrary to one of the fundamental rules of philosophizing, that which forbids us needlessly to multiply causes. For we are thus driven to suppose two kinds of Intelligence, human and brutal, and two sets of faculties, a Memory and a Quasi Memory, as the lawyers would have it—an Abstraction and Reasoning, properly so called, and something in the nature of Abstraction and Reasoning, but, though like, yet not the same.

A. There is one matter to which we have not as yet adverted, but, after having considered the intelligent as well as instinctive powers, we may now as well do so. I mean the diversity in the operations of the latter, and the perfect sameness of the former—a sameness in all the operations of any given individual animal, and likewise of each of the species.

B. This is well worthy of consideration. When trying to explain instinctive operations upon the hypothesis of an intelligent principle acting under the impulse of sensations, I found in this perfect sameness and regularity of its operation a considerable difficulty, though not perhaps an insuperable one, not certainly so great a difficulty as those we have considered.

A. How did you endeavour to explain, on that hypothesis, the regularity of Reason or Intelligence?

B. The absolute sameness of moral and intellectual character, and the limited sphere of ideas and events, will account for much. We see far less diversity of action and speech among peasants of a very confined knowledge and very limited range of pursuits, than among persons of a higher degree of education and superior station in life. But still there is a great diversity. Taking, however, two men of most perfect resemblance in all their faculties, and all their feelings, similarly constituted in both body and mind, they would probably act nearly if not entirely alike. Whatever made one do a thing would make the other, and we must suppose them to be placed in perfectly similar circumstances, so that the same things would happen to both. Chance is here to be put out of view; because *it only* means ignorance of motives and circumstances, and assumes a diversity in these unknown to us, which by the supposition is here excluded. Suppose these two individuals thus placed in like circumstances as to food and building materials, why should they eat differently, or make different habitations? What is there to make the one choose a plant which the other does not choose? or form a hut in any particular different from the other? If one kind of food was nearer the one, and another nearer the other individual, they might choose differently; but this assumes that both kinds are agreeable to the constitution of their palates.

A. As long as providing for merely physical wants was their whole occupation, it is probable that both would act alike, except that, if any difficulty occurred to be vanquished, I am not at all sure of their adopting the very same means to overcome it. One might break a nut with his teeth, another with a stone, or by bruising two nuts together. But there is the same diversity in the conduct of animals where they act by intelligent principles. The general resemblance of their proceedings is explained by the consideration you are stating in the case you put of the boys. Their instinctive operations would never vary in the least particular. When they came to reason, or speculate, or converse, the sameness would probably cease. It seems inconsistent with imagination and with free will; yet of this I speak doubtingly, considering the hypothesis you have made of faculties and feelings perfectly alike in all respects.

B. Certainly, you ought to speak doubtingly, when such is the hypothesis that is now binding us. I do not see how, even in reasoning, anything should ever come into the mind of the one that did not suggest itself to the other. But our hypothesis is not easy to remain under. Suppose, to make the case like instinct, two untaught children in different parts of the country, viz., one in China and the other here, to be placed in a situation where the same kinds of food and building materials were placed, and a variety of each, we may assume that similar tastes and constitution of mind and body would make them eat the same things, perhaps choose to shelter themselves by building rather than by going into caves, possibly to build with the same materials selected out of a number; but it is much to say that they would exactly preserve the same figure and size and proportions in the huts they made. Each would certainly make blunders, and work inartificially; and it is difficult to fancy them exactly making the same blunders, deviating from the straight line or the circle by the same quantity of aberration, and from the perpendicular by the same angle: yet the bee in China and in England makes the same angles, and forms cells with the same proportions, and raises the grub the same height from the liquor provided for its nutriment, so as to let it have access to the liquor without incommoding or drowning it.

A. When instinct is interfered with by obstacles interposed, the animal's intelligent powers are brought into action, and then the uniformity and perfect regularity ceases. This seems to present under this head, as well as the other head of knowledge and design or intention, a sufficiently marked distinction.

B. Certainly; and it is to be observed that the more sagacious any animal is, the greater variety is perceived in his actions and habits. Thus the elephant and the dog present general resemblances throughout each species; but the instances of sagacity or reason which the different individuals exhibit are sufficiently various: whereas there is no more diversity in the ordinary working of the bee, than in the operations of crystallization, or the secretion of the sanguiferous or the lacteal system. In truth, we may compare the two cases together. Instinct seems to hold the same place in the mental which secretion and absorption do in the physical system. Intelligence or reason will *sometimes* interfere with Instinct, as our voluntary actions will interfere with the involuntary operations of secretion. But the instinctive operation proceeds whether the animal wills or no—proceeds without his knowledge, and beyond his design—as secretion goes on in our sleep without our knowledge and without any intention on our part. So as secretion goes on without any help from us, or any direct co-operation, Instinct works without any aid from Intelligence. But there is this difference in the connexion of will or Intelligence with Instinct, and the connexion of voluntary action with secretion—that the Instinct seems subservient to the intelligent will far more than the secreting power is to the voluntary action. The bee, when obstructed, applies his Instinct, as it were, to overcome the obstacle, whereas we cannot alter at will the course of secretion; we have some direct power over it, but very little.

A. One thing seems quite clear, that upon any view of this great question, whatever theory we adopt, all leaves the inference of design untouched; nay, the more we inquire, the more we perceive that all investigation only places in a stronger light the conclusion from the facts to a superintending Intelligence.

B. Beyond all doubt it is so. The whole question is one of relations and connexions. Adaptation—adjustment—mutual dependence of parts—conformity of arrangement — balance — and compensation — everywhere appear pervading the whole system, and conspicuous in all its parts. It signifies not in this view whether we regard Instinct as the result of the animal's faculties actuated by the impressions of his senses—or as the faint glimmerings of Intelligence working by the same rules which guide the operations of more developed reason—or as a peculiar faculty differing in kind from those with which man is endowed—or as the immediate and direct operation of the Great Mind which created and which upholds the universe. If the last be indeed the true theory, then we have additional reason for devoutly admiring the spectacle which this department of the creation hourly offers to the contemplative mind. But the same conclusion of a present and pervading Intelligence flows from all the other doctrines, and equally flows from them all. If the Senses so move the animal's mind as to produce the perfect result which we witness, those senses have been framed and that mind has been constituted, in strict harmony with each other, and their combined and mutual action has been adjusted to the regular performance of the work spread out before our eyes, the subject of just wonder. If it is Reason like our own which moves the animal mechanism, its modification to suit that physical structure and to work those effects which we are unable to accomplish, commands again our humble admiration, while the excellence of the workmanship performed by so mean an agent impresses us with ideas yet more awful of the Being who formed and who taught it. If to the bodily structure of these creatures there has been given a Mind wholly different from our own, yet it has been most nicely adapted to its material abode, and to the corporeal tools wherewith it works; so that while a new variety strikes us in the infinite resources of creative skill, our admiration is still raised as before by the manifestation of contrivance and of expertness which everywhere speaks of the governing power, the directing skill, the plastic hand. Nor is there upon any of these hypotheses room for doubting the identity of the Great Artificer of nature. The same peculiarity everywhere is seen to mark the whole workmanship. All comes from a Supreme Intelligence; that intelligence, though variously diversified, preserves its characteristic features, and ever shines another and the same.

NOTE TO THE DIALOGUES.

IN Dialogue I. the Instinct of the duckling hatched under the hen and of the chicken in the oven is mentioned. The two following facts have occurred since that discussion was ended.

When a sow farrows, the pigs are expelled with some force, and to a little distance, by the action of the uterus and abdominal muscles. Each pig instantly runs up to one of the teats, which he ever after regards as his own peculiar property; and when more pigs than teats are produced, the latter ones run to the tail of some of the others, and suck till they die of inanition.

Mr. Davy in his account of Ceylon mentions a remarkable Instinct of the alligator. He saw an egg in the sand just ready to crack, and broke it with his stick. The animal came out, and made at once for the river. He held his stick before it, and immediately the reptile put itself in a posture of defence, as an adult alligator would have done in like circumstances.

In Dialogue III. there is some doubt expressed as to the water-moth loading its case, if too light in the water, with a kind of ballast. The larvæ of the *Phryganea* are stated by Mr. Lyell to do this habitually, and to use fresh-water shells for their ballast. This gives rise to many masses of calcareous matter in the tertiary formations. As many as 100 small shells are found surrounding one tube.*

In Dialogue IV. some remarks are made upon Hereditary Instincts. Mr. Roullin has related a similar instance of such Instinct in the hunting dogs of Mexico. Were they to attack the deer in front, whose weight exceeds their own sixfold, they would be destroyed and have their backs broken, as happens to other dogs ignorant of the manœuvre, which consists in attacking from behind or laterally, and seizing the very moment when the deer, in running, rests upon two legs. The dog then takes hold of him by the belly and throws him over. The dog of pure breed inherits this stratagem and never attacks otherwise. Should the deer come upon him unawares (from not seeing him), he steps aside and makes his attack at the proper time in the animal's flank; other dogs, however superior in sagacity and strength, make the attack in front, and have their necks broken by the deer. So too some of our English miners carried out greyhounds to hunt the hares in Mexico. The air on that elevated platform,

* Principles of Geology, vol. ii., p. 232.

9,000 feet above the level of the sea, is so rare that the mercury stands at 19 inches generally, and the dogs were soon exhausted with running in such an atmosphere; but their whelps are not at all incommoded by it, and hunt as easily as the dogs of the country.

Respecting the elephant, extraordinary accounts are told by military men who were in the Burmese war. They relate that when any extra task is to be performed by them, some favourite dainty is held up beforehand, and the sagacious animal, comprehending the promise of reward thus implied, exerts himself to earn it. This comes to the principle of barter as near as may be.

APPENDIX.

I.

ON THE GLOW-WORM.

THE facts relating to the light of this and other similar insects are by no means accurately known; and upon some material points able observers differ widely. Thus it was deemed very natural to suspect that some inflammable matter in a state of slow combustion caused the luminous appearance, the rather as it bears a striking resemblance to the light emitted by phosphorescent bodies. Accordingly the obvious course was pursued by different experimenters, of exposing the insects to heat and to oxygen gas, to see if the light was increased; and exposing them to carbonic acid and hydrogen gases, to see if the light was then extinguished. Forster and Spallanzani affirm that they have tried this experiment, and found the result to accord with the theory; they assert distinctly that in oxygen gas, and on the application also of heat, the light is more brilliant, and that none is given out in hydrogen and carbonic acid gases. But Sir H. Davy found that the light continued in the latter gases not sensibly diminished, and that oxygen did not increase its brightness;* Mr. Macartney observed the light in vacuo and under water,† while Dr. Hulme found that it was extinguished in hydrogen, carbonic acid, and nitrous gases, although he could not perceive that oxygen gas increased.‡ There seems reason to suspect that these able men made their experiments on different species of the insect, and that the animal or vital powers which regulate the secretion, or the use of the luminous matter, were affected by the gases applied. For it is admitted on all hands that the living insect has a power of extinguishing the light independent of any mechanical operation by which it may cover over the shining part; and although the fire-fly has that part usually covered with its wings, and therefore only shines when flying, the glow-worm's light is constant, unless she restrains or extinguishes it by a voluntary act.

That some luminous matter is secreted by the insect there can be no doubt. The fact that boys in South America rub their

* Phil. Trans., 1810, p. 287. † Ib., 1801. ‡ Ib., 1810.

faces with bruised fire-flies, to make them shine, is asserted by travellers; and this seems to render it probable that the glow-worm likewise secretes such an oil. But the experiments of an able chemist, Mr. Murray, have set this question at rest. He examined a box in which glow-worms had been kept, and found several luminous specks which they had left behind them. Some of these yielded a steady light for five or six hours. Mr. Murray says that the luminous matter is enclosed in a capsule of a transparent substance, which, when ruptured, lets out the matter in a liquid form of the consistency of cream. A French naturalist, M. Macaire, made some experiments upon this matter, the result of which differed materially in one respect from that of either Spallanzani, Davy, or Hulme; for he is said to have found that the presence of oxygen in the air prevents it from shining, a position not reconcileable with the worm shining in the atmosphere. But some of this author's experiments seem to furnish a solution of many difficulties; for their results refer the appearance to the animal functions. He found that the luminous matter is chiefly composed of albumen, and that any body which coagulates albumen destroys the shining quality; which it probably does by altering the albuminous state of the fluid. He also observed, that though a certain degree of temperature is necessary for it, a higher degree destroys it altogether; and also that common electricity has no effect in exciting it, but that voltaic electricity or galvanism does excite it. These observations, if accurate, are the most important that have been made upon this subject. They seem to indicate an immediate connexion between the vital powers of the insect and its luminous quality; and they account satisfactorily for the diversity in the results of former observers, who operated upon the animal apparently without taking its vital functions into the account.

The glow-worm (Lampyris Noctiluca) is not the only luminous insect. There are several other kinds both winged and apterous. Of these the fire-fly, a species of the Elater and of the beetle tribe, has already been mentioned. Indeed all the species of the Lampyris genus are supposed to be more or less luminous. Several other species of the Elater, as well as the fire-fly, are also luminous. Some species of the Fulgaro (an hemipterous insect) shine so bright that they are called lantern flies. Of these the Fulgora Candelaria is a native of China, and the F. Lanternaria, which is two or three inches long, is a native of South America. The shining matter in these, and all others of the genus that shine at all, is confined in a transparent bulb projecting from the head.* Two species of centipes, the Geophilus

* Kirby and Spence, ii., 413.

Electricus and G. Phosphoreus, also shine; the former is a native of this country, the latter of Asia.

Several theories have been formed to explain the use of this luminous quality. It is observable that some of the insects which have it are apterous in one sex while the other is winged—as the glow-worm, the male of which is a fly, the female being a caterpillar. In others both male and female are winged. Again, some have the light always in front, and it seems not to vary in brightness, as the Fulgora. Naturalists have supposed that in these it is serviceable in discovering their prey. But it has also been suggested that defensive or protective purposes may be the final cause of the light. Insects which prey on caterpillars have been observed running round the Geophilus Electricus as if afraid to approach it.* But there is one peculiarity in the glow-worm's light which seems to sanction the commonly received opinion of its use being chiefly, if not entirely, to attract and direct the approach of the male. Not only has the latter wings, and thus is by his habits little likely to be found near the unwinged female—there is also found to be much less light emitted by the male; insomuch that at one time the female alone was believed to shine at all, until Ray corrected this error. It is also remarked that the light is the strongest when the two are together, and that in some, if not all the species, the luminous quality is confined to the time when they are destined to meet. Nor is De Geer's objection, founded on the observation that the chrysalis and larva of the species have somewhat of the same luminous quality, of much force. For as the very learned entomologists just cited, Messrs Kirby and Spence, have well observed, this instance may easily be set down with the analogous case of males having a kind of lacteal system in some animals, including our own species. It deserves further to be remarked, that in Brazil there is a glow-worm which is winged, both male and female, and the light given by this insect is not steady like that of our glow-worm, but sparkles or intermits. On the other hand, the fire-fly of Brazil is said to give a constant light.† But this may be owing to the greater luminousness of the tubercles in the thorax, which in the European fire-fly give so little light compared with the patches concealed by the cases (elytra) of the wings, that they seem only to shine when flying.

* Kirby and Spence, ii., 225. † Kirby, Bridgewater Treatise, ii., 366.

II.

OBSERVATIONS, DEMONSTRATIONS, AND EXPERIMENTS UPON THE STRUCTURE OF THE CELLS OF BEES.

The principal use of the cells in the comb is to provide places where the eggs may be deposited, the worms hatched, the pupæ or chrysalides formed, and the bees afterwards produced. The cells are also used for storing the bee's bread and the honey. But, to whatever use they are applied, it is of importance that in their construction the greatest possible saving should be made, both of space, of wax, and of labour.

The importance of saving room is obvious, quite independently of that saving conducing to an economy of wax and of labour, in the construction of the cells; for the whole hive may thus be made in places which would otherwise be too confined; the heat necessary to the health of the bees, to the process of hatching, and to the preservation of the honey, is thus economized; the labour of the bees in moving about the combs to superintend the various operations after the buildings are finished is materially abridged; the more compact each comb is, the stronger it will prove; and the fewer the interstices are, whether between the different combs, or between the cells of each, the greater will be the security against intruders.

The saving of wax is equally, perhaps more, important. That material is not abundant. It nowhere exists in nature; but is elaborated by the bees themselves. This capital discovery we owe to John Hunter and to Huber; but the step was principally made by the former. He found* that small rings or films of wax are protruded through the scales of the bee's belly; and Huber afterwards showed that this is secreted in the stomach, when the bee feeds either upon honey or other saccharine matter. But, beside the limited amount of such matter, the process of secretion appears to be one of time and difficulty, requiring the animal to be at rest, and in certain attitudes. Moreover it is only one class of the hive that can produce wax at all. Nor is the wax when secreted in the stomach and given out through the scales in a state fit for use. It undergoes another process by the work of the bee, who moistens it with saliva, kneading it and working it, to give it the ductility, consistence, and opacity required. The building or sculpturing

* Phil. Trans., 1792.

bee is observed to take into her mouth part of the scale furnished by the wax-worker (or bee producing wax), to work it about in her mouth, and to bring it out in the form of a long and slender thread or ribbon, which she coils and turns, and again and again passes through the mouth, until it is quite fit for building with. The limited supply, therefore, of this substance, as well as the labour required to prepare it for use, renders the economical employment of it a matter of great moment.

Lastly; it is evident that, although the saving of room and of wax were immaterial—supposing, for example, the saving of heat and increased strength or solidity not to be required, and a supply of wax ready for use without any labour in preparing it to be unlimited—still the construction would be the most advantageous which required least work, and enabled the bees to perform the operations allotted to them, of building, storing, and breeding, within the season to which their activity is confined. This saving is probably the most important of the whole; because the possibility of continuing the species may depend upon it. The two other savings, of room and of wax, conduce materially to this saving of work; but work may also be saved, independently of those two other savings, by the form and arrangements of the structure.

The mutual connexions of these three savings, as well as their possible independence of each other, may be illustrated by supposing a house with so many, say three, rooms required to be built, where land is dear, roofing materials scarce, and labourers few, or the time for finishing limited. Build the three rooms all on the ground floor, and you require more land, and more roof, and more labour than is necessary. Build them one above another, and you save in all the three particulars. But though there were no want of land, or of roofing materials, but only of workmen, or of time, build the three rooms on the ground, and at a distance from one another, and you lose unnecessarily work and time.

If we now conceive a given space which is to be used by the bee, and consider in what way the cells must be disposed in order to bring the greatest number possible within it, and not interrupt the operations of the animal, we shall be able to perceive the arrangement best suited to effect a saving of room.

The size of the cell, both as to length and breadth, must be determined by the dimensions of the young insect in its last stage before coming out a perfect bee, though no doubt the cells used for storing honey and bees' bread may be larger or smaller. The manner in which the cells must be disposed is in some measure also determined by the length; for one of the ends must be left open, and there is no necessity for the other being open; on the contrary, its being closed accommodates and protects the egg when deposited there, and the worm when first hatched. Therefore the cells should be arranged in double rows, with their ends in contact on one side and open on the other. This is the only disposition of them by which an interval between the two rows can be saved, and therefore the whole number of cells which are to be made in the given space must be disposed in double sets or rows, the cells on each side or face abutting on those of the other. Between each row or set—say comb—and the next, a space must be left sufficient for the bees to pass and repass; and to avoid the necessity of their going round in order to get from one vacant space or street to another several openings must be made in each comb, as it were cross streets, leading from one to the other main street. This is a sacrifice of room to save labour and time.

But in what way must the cells be made so as to place the greatest number in each set or comb? This leads us to consider the form of the cell, which must be such as both to accommodate the insect and to leave no interval between cell and cell. The form must correspond as nearly as possible with that of the insect, which both in the grub and perfect state approaches to cylindrical. But if the cells were cylindrical, there would necessarily be interstices. If it is required to fill any given space* with a number of equal and similar figures disposed in the same way, and each circumscribing a cylinder, there are only four which can be formed without leaving any interstices—the prism whose section is a parallelogram; the prism whose section is an equilateral triangle; the cube or parallelopiped, whose section is a square, and the hexagonal prism. If the inscribed cylinders are required to touch one another in four points, the first kind of prism must be rejected.† Let us take the sections only, for

* The proposition must be limited in some such way as this. Nothing can be more incorrect than the usual statement of it, that the equilateral triangle, square, and hexagon, are the only figures which will fill space, unless it be meant of regular figures, that is, figures inscribed in a circle. But then the circumscribed circle is immaterial, and so is the equality of sides. The question is as to the circle inscribed. If the condition that the solid be one circumscribing a cylinder is not added, then equal and similar hexaedral pyramids, or frusta of these, would answer the condition of filling the space without leaving interstices, and we shall see that there are instances of a structure approaching to this in the wasp's nest.

† There would also be no limits to the loss of space internally so formed, nor to a certain loss of space externally, viz., at the edges or outward boundary of the given space; but if the figures are to be ranged round a given

whatever is true as to the surface of the section must be true as to the solid contents generated by apposition or by motion of that surface. The square, the equilateral triangle, and the hexagon, are therefore the three figures which answer the condition of leaving no space unemployed.

But if the square or the triangle were chosen, though no space would be lost on the outside of the comb, and between the different cells, space would be lost on the inside of each cell, because the circular form of the insect would leave the angles empty. There would be more space thus lost in the triangle than in the square, and more in the square than in the hexagon. The radius of the circle representing the insect or grub being r, the space lost in the triangle would be $3\sqrt{3}\,r^2 - C$; in the square $4r^2 - C$; in the hexagon $\frac{6r^2}{\sqrt{3}} - C$; C being the area of the circle. Consequently the triangle would occasion more space to be lost than the square by the amount of $(3\sqrt{3} - 4)\,r^2$, and than the hexagon by the amount of $\sqrt{3}\cdot r^2$, while the square itself, though occasioning less loss than the triangle, would occasion more than the hexagon by the amount of $\frac{4\sqrt{3} - 6}{\sqrt{3}} \times r^2$. If r be taken equal to unity, the loss of the triangle compared with the square would be about 1·19, and compared with the hexagon about 1·73, and the loss by the square compared with that by the hexagon would be about ·53. So that suppose a comb a foot square, and containing, both sides included, 4,608 cells, allowing a quarter of an inch for the breadth of each, and one-eighth of an inch for the radius of the circle (or insect), the loss of the triangle compared with the square would be above 85 square inches, or the room for 1,360 bees; the loss of the triangle compared with the hexagon would be 124 square inches, or room for 1,984 bees; and the loss even by the square compared with the hexagon would be above 38 square inches, or room for more than 608 bees.* The loss of space upon a whole hive of a cubic foot, supposing the combs an inch thick, and the interstices between them half an inch, would of course be eight times as much; so that such a hive would have more space by

point, such parallelograms would certainly answer the conditions. Triangular prisms would also fill the space, but then they could not, to do so, be all disposed in the same manner.

* Upon the supposition of the cells being a quarter of an inch in breadth, and consequently the radius of the circle one-eighth, in any plane containing the comb, the loss of space in each cell, if triangular, would be about $\frac{1}{32}$ of an inch square; if square $\frac{1}{72}$; and if hexagonal, only $\frac{1}{198}$, or a ninth of the loss by the triangle, and two-fifths of the loss by the square.

992 cubic inches, and room for above 15,800 more bees, if the cells were hexagonal, than if they were triangular, and more space by 304 cubic inches, and room for above 4,864 more bees, than if they were square. But as these calculations proceed upon the supposition of the same number of cells being crowded into the space, whatever be their form, we may only take the supposition, which would certainly be more correct, of different numbers being crowded according to the form; viz., for the triangle 3,546, the square 4,608, and the hexagon 5,320. This would make the loss in the three figures, respectively, for the whole comb, 113, 61, and 26 square inches, being accommodation for 2,326, 1,260, and 543 bees respectively; or the loss on the triangle, as compared with the hexagon, 1,783 bees, and on the square, 717.

Nor are these computations confined to the case of the grub or the insect being regular cylindrical bodies. They only assume that the cell is to be of such a diameter as to contain the animal; and therefore that in some one part of the prism or parallelopiped the circular section of the animal touches the sides. The result of the computation is the same as to the space lost, whatever form the rest of the animal may have. Indeed, as C (the area) vanishes from the equation, the section of the animal needs not be circular,* so that there is room for its greater axis; only the whole reasoning rests upon the supposition of the given space being divided into figures within which a circle may be inscribed touching each side. If the insect were of an oval form, and especially one of great eccentricity, the most economical division of the space would be into parallelopipeds, whose sides were tangents to the ellipse.

It is equally clear that if the cells were formed cylindrically, although there would be no loss of space in the inside, supposing the insect cylindrical, and that the loss would be the less the nearer its shape approached to the cylinder; yet the space between the cells would be a loss. Suppose they were arranged as close as possible, and so as to make the interstices the smallest possible, they must be placed around one in the centre, and touching it and each other. Therefore their tangents would form hexagons. Then the interstices or circular triangles would be space lost. This loss would (taking the surface as before) be between the cell in the centre, and the surrounding six, equal to $\left(\frac{6\,r^2}{\sqrt{3}} - \mathrm{C}\right) \times 3$ or $\sqrt{3} \cdot 6\,r^2 - 3\,\mathrm{C}$ equal to $1 \cdot 02\,r^2$

* This is only applicable to the calculation in the text; the computation in the last note giving not the relative but absolute loss of space, proceeds upon the supposition of a circular area.

nearly; between every four cells the interstices would be $\cdot 34\, r^2$, and between every three $\cdot 17\, r^2$; and the space in the first mentioned interstices would be $\frac{1}{82}$ square inch, on the former supposition of the radius being $\frac{1}{8}$ inch; in the second mentioned interstices $\frac{1}{188}$, and in the third $\frac{1}{376}$ square inch. The whole loss of space on a comb of 4,608 cells would be 4,607 times the space lost between any three cells—that is about $783\, r^2$—or (on the former supposition of $r = {}^{1}$) about $12\frac{1}{4}$ square inches, beside the loss on the outer edge, which would depend on the form of the boundary line of the comb. In any other disposition of the cylindrical cells the space lost would be much greater, and it could not be made less than this by any arrangement.*

It is evident that the saving of space by leaving no interstices between the cells is material, whatever use may be made of those cells. But the saving of space within each cell is only material where the cell is to be used for the lodging of the insect or its brood. Where it is to be used for storing honey or bee's bread, as these fill it, the form becomes immaterial. Therefore triangular or square cells, exhausting the whole space, and leaving no interstices, would have been as economical an arrangement as hexagonal ones for the cells used to store provisions. They would, however, have had no advantage for this purpose over the hexagonal ones; indeed there would, especially in the triangular ones, have been some inconvenience in depositing the stores, because the bee could not so easily have reached every part of the cell. It thus appears that, supposing there were no consideration to enter the calculation except the saving of space, the hexagonal form is the best of any. But the saving of materials and of labour leads to the same conclusion still more strongly.

Suppose, now, therefore, that the space is of no moment, and that saving room is immaterial, and consider only the saving of wax. If the form of the cell were circular, or of any other curve, it is manifest that each cell must have its separate walls, as the neighbouring cells could only touch in one point each; and if the figure were rectilinear, but such as to leave interstices, the cells must have separate walls wherever these interstices occurred. The only figures which could enable each cell to afford walls for the contiguous ones, and thus to make each wall serve for two cells, are those which fill up the space without intervals, that is, the triangle, square, and hexagon. But it has been shown that in any given space more hexagonal cells than square or triangular cells can be placed. But let the proportions of the peripheries of these cells be considered, and we shall see more clearly the saving of wax and work effected by the hexagonal form. The triangular cell (it is immaterial

* See note at the end of this dissertation.

whether we take the plane or the solid figures in stating the proportions) has a periphery of $\frac{18\,r}{\sqrt{3}}$, r being the radius of the insect or inscribed circle — the square $8\ r$ and the hexagon $\frac{12}{\sqrt{3}}\ r$ — consequently these figures require materials and labour to form them capable of containing the same kind of insect in the proportions of $10 \cdot 4$, 8, and $6 \cdot 9$; and the saving by the hexagonal form is therefore above one-eighth, compared with the square; aud one-third as compared with the triangular form. It is true that the circular form upon a single cell would save even as compared with the hexagon—just as it would save room inside. The periphery would be about $6 \cdot 28$, or about a tenth less than the hexagons. But then the loss on several cells would be very great, because each cell must have separate walls; and we shall presently see in what proportion that would increase the expenditure of materials and labour. It may be sufficient here to observe, that suppose a circular (or cylindrical) cell surrounded by six others; the walls of the whole seven would be about $44\ r$. Whereas if a hexagon cell is surrounded by six others, there are only 30 sides wanted instead of 42, and the whole amount is something less than $35\ r$, or a saving of one-sixth.

It thus is demonstrated, that supposing the combs to be constructed of double sets of cells, each set open at one end, as they must be for the purposes of the bees, and that all the cells are of the same form, there is no form which could be chosen and no arrangement of the cells which could be made to save so much room, wax, and work as the hexagon form, and the disposition of the cells, as to make each wall serve for two. It is also clear that, if they are to be entirely of one form, and that the hexagonal, the greatest saving will be effected by making their common junction, that is where the closed ends meet, one plane, so that the same hexagonal bottom shall serve for the opposite cells. But a much more refined contrivance is found in this part of the structure, and one better suited to the purposes of the animal, by which a considerable additional saving is made both of space, materials, and labour, and a considerable gain effected in solidity and strength. The hexagonal form, so well fitted for all the rest of the cell, is not the best adapted for its bottom; and the form of a prism, which the cell has in the greater part of its length, is changed when we approach the bottom. Let us now consider the use to which the bottom is applied, in what manner that purpose can best be answered by the form, and how that form can be best made to suit the purposes of the strict economy which is consulted throughout the whole structure.

For storing honey and bees' bread it is plainly immaterial how the space contained in the two opposite hexagonal prisms is divided; and a plane cutting them across, that is, giving to each cell a hexagonal bottom, and making that common to both, would afford the same room for the stores with any other construction. But it is not so with the other uses of the cells. The egg first deposited, and the worm in its earlier stage, require only a narrow space; and even when it has grown to its full size, from its tapering form it can easily be accommodated in a cell with extremities considerably narrower than the rest of the space. This is especially the case with the tail part, which is at the bottom of the cell; it is much more taper than the rest of the body, and considerably more so than the head, both in the grub and fly. If then the hexagonal form were preserved throughout, there would be a considerable waste of room towards the bottom. Suppose we had to pack two sets of parcels together each opposite to the other; if they were equally thick or broad throughout their whole length, as, for example, Stilton cheeses, we should place them one set upon or against the other, and could lose no space by this arrangement, nor gain any by another arrangement. But suppose each parcel tapered towards one end, like pears, or like wedges cut out of the cheeses; we should then lose room by placing the narrow ends opposite each other, and should save considerably by inserting the tapering ends of the one set of parcels in the vacant spaces left by the tapering of the other. The narrow end of each parcel would thus be inserted between the narrow ends of two others; and the whole space in which all the parcels could be packed would be shortened by the length of the centre line or axis of the parcels, reckoned from the part where the tapering begins to the narrow extremity. This is exactly what is done in the comb; each cell, from being a prism, becomes at the closed end a pyramid, terminating in a point; and the narrow end of the animal is thus placed between the narrow ends of these on the opposite side of the comb, so as to enable all of them to have the room required by their shape and size, with cells shorter than they must have been had each cell abutted on the single one opposite to it, and not been inserted, as it were, between several opposite ones.

But a further contrivance is necessary that no space may be lost between those oppsite cells, and that the same bottoms may serve for both the opposite sets, else the hexagon common to both would have been more economical as to work and materials. The pyramids must be so formed as that each of its sides shall be one side of the opposite cell's pyramid. This is accomplished by the pyramid being trihedral, or composed of three planes, each of four sides. But if these three planes are inserted in the prism, they must cut off a portion of each of its walls; and it will depend upon the amount of this portion how far the surface of the whole pyramid shall be greater or less than the hexagonal bottom would have been. If a pyramid were raised upon the extremity of the walls of the cell to serve instead of the hexagonal bottom, its surface would manifestly be greater than that hexagonal bottom; but it is evident that, by inserting the pyramid partly in the angles of the hexagon, so much of the walls may be cut off as will make the whole surface that is left, walls and pyramid together, no greater than the whole walls and the hexagonal bottom would have been. But it is proved that so much of the walls may be thus cut off as to make the pyramid, together with what is left of the prism, have a smaller surface than the whole walls of the prism together with the hexagonal bottom.

Thus if this construction be adopted, each cell will be opposite to three others; its pyramidal bottom will consist of three plates or sides, each of which is the side of an opposite pyramidal bottom; the pyramid therefore furnishes on the one side the whole bottom of one cell, and on the opposite side it furnishes one-third of the pyramidal bottom of three other cells; wherefore it serves for as much bottom (for the bottoms of as many cells) as the hexagonal bottom could have done; and while room is saved by the cells being shortened as much as the height of the pyramid above the original prism, or half the whole height of that pyramid, wax and work are saved by the whole surface of the cell being less than it would have been had each cell been a prism terminating in an hexagonal plane. As for the solid space contained in the figure formed by the remaining part of the prisms and the pyramidal bottom, that will be exactly equal to the space contained in the prism terminated by the hexagonal plane, and before any part was cut off by the pyramidal sides; for the space contained in the whole pyramid is exactly equal to what is cut off from the prism together with the part of the prism which is left in the pyramid. All this is clear from the nature of the hexagonal prism and of the trihedral pyramid; and it also follows from the nature of those figures that each of the three sides or planes of the pyramid must be a rhomboid or figure of four equal sides; for the side of the pyramid must be inserted in the angle of the hexagon, whose sides being equal, so must the two sides of the pyramidal side inserted; and in order that the apex of the pyramid may be in the axis of the *prism*, which is necessary to make the opposite pyramids coincide, and the same sides serve for both the sets, the other two sides of the pyramidal side must be inserted in the opposite and equal hexagonal prisms, and must therefore be equal to the sides inserted in the first prism.

But we have not yet found what must be the altitude of this pyramid; or, which is the same thing, at what points the sides of the prism must be cut in order to form the bottom of the cell; or, which is the same thing, what must be the angle of the rhombus forming the pyramid's sides, regard being had to the proportion, which will make the whole surface the smallest. Thus if the top of the pyramid is a very little above the hexagonal bottom of the prism, the whole surface of the pyramid will be somewhat less than the whole surface of the hexagonal bottoms, together with the six triangles cut off from the walls; if the top is a little higher, the difference will be somewhat greater. But increase the height, and that difference will begin to lessen till it vanishes altogether, and at that point there will be no saving of surface, the pyramid being equal to the hexagonal bottom together with the six triangles cut off. Raise it higher still, and there will be a loss. Consequently, there is a point at which the saving will be the greatest possible. We may either inquire what that point is, in other words, what the altitude must be of the pyramid—or we may inquire what proportion the side of the rhombus must have to the side of the hexagon—or what must be the angles of the rhombus—or at what angle the rhombus must cut the sides of the prism—or at what angle the rhombuses must meet each other—or what must be the breadth of the rhombuses. Any one of these things being found, all the rest are determined.

The investigation gives the following result. The breadth of the rhombus—that is, a line drawn from any of the angles perpendicular to the opposite side—must be equal to the side of the hexagon; and it will follow from this, one of the diagonals of the rhombus being the diagonal joining the alternate angles of the hexagon, that the rhombuses are inclined to one another at angles of 120°, being the angles of the hexagon, in other words, the rhombuses must be a continuation of the hexagonal sides, and their angle a continuation of the angle of those sides. Hence, too, it will also follow that the side of the rhombus must be to that of the hexagon as 3 to $2\sqrt{2}$; the rhombus cuts the prism at a distance from the upper part of the prism equal to $\frac{1}{2\sqrt{2}}$ of the hexagon's side; the altitude of the pyramid is $\frac{1}{\sqrt{2}}$ of that side; or that altitude is to the side in the proportion of the side of a square to its diagonal; and, finally, it also follows, that the obtuse angle of the rhombus is 109° 28′, and the acute angle 70° 32′.

Let us now look to the fact, and observe whether or not the combs are constructed according to what the mathematical reasoning proves to be the best possible plan for saving surface in the cells.

In the *first* place, the cells are obviously fitted into each other as the theory requires; for the prismatic form is not continued to the end, but each has a pyramidal bottom or base, and that base is composed of three planes, each of which forms one side of the bases of three opposite cells, so that one set of those planes serves for the opposite pyramids; each cell is over against three cells on the opposite comb, and each cell has its base common to itself and those three opposite cells. The length of each cell is thus shortened without lessening the accommodation of the grub, or pupa, or bee; for in each of those states the pyramid is large enough, considering the tapering of the animal's form, and any wider space at the tail part, which is always inserted in the pyramid, would be so much room thrown away. *Secondly;* the form of the pyramid is that which the theory requires, in order that there may be no interstices, and that the pyramids may fit the hexagonal prism exactly:—the sides of each pyramid are three equal rhombuses. *Lastly;* each rhombus has the precise angles, and, consequently, as it is inserted in the hexagon, the precise length of sides also, which the theory requires in order to effect the greatest saving of surface in the work. For M. Maraldi, having measured the angles of the rhombus, found them to be 109° 28′ and 70° 32′, respectively. Therefore the other proportions must follow, and the precise point of the maximum is obtained by the bees; or they construct the bottoms of the cells in the form and of the proportions which enable them to gain the most space, and to save the most wax and work, of any forms and any proportions that could be imagined.

This eminent person, however, was not aware that those conditions had been fulfilled, and this result obtained by the bees. He saw that the pyramidal form of the base, and the fitting of the opposite rhombuses, saved both space and material in a considerable degree. He could not doubt that in order to fill the space, and make one set of pyramids serve for the opposite sets of cells, it would be necessary that the section of each pyramid should be an equilateral triangle, and consequently that the sides of each pyramid should be three in number, and equal to each other. Nor could he fail to perceive that the hexagonal figure of the cell, into which those sides were to fit, required that each *should* be a rhombus. But the three equal rhombuses might have an infinite variety in their angles; their sides might have proportions infinitely varying to the sides of the hexagon; and the pyramid formed by them might have infinitely various altitudes; and yet the same general structure might be preserved. The reason for the precise angles and proportions observed by M. Maraldi was not perceived by this distinguished mathematician. Though upon the verge of making the discovery, he contented himself with observing the angles, and did not ascertain that they were precisely such as made the saving the greatest possible.

This was reserved for a subsequent period; when M. Reaumur having considered the structure and the measurement of the angles, with the sagacity which peculiarly marked that great man, conjectured that this maximum point had been attained by the bees; but as no investigation of the question had ever been undertaken, it was only a conjecture. However, he soon took steps for changing it into a certainty. He proposed to M. Kœnig, an expert analyst, pupil of the celebrated Bernouilli's, the solution of the problem—To find the construction of a hexagonal prism terminated by a pyramid composed of three equal and similar rhombuses (and the whole of given capacity), such that the solid may be made with the least possible quantity of materials—which, in other words, was asking him to determine the angles of the rhombuses that should cut the hexagonal prism so as to form with it the figure of the least possible surface, since the hexagon being given this decided both their dimensions and their intersections with the sides of the cell. He did not inform M. Kœnig of Maraldi's measurement until after he had solved the problem, and had assigned 109° 28′ and 70° 34′ as the angles, when he sent him the 'Memoirs of the Academy of Sciences' for 1712, containing M. Maraldi's paper, and M. Kœnig was equally surprised and pleased to find how nearly the actual measurement agreed with the result of his investigation. The difference was only two minutes; and it has generally been supposed since then either that M. Maraldi's measurement was erroneous, or that the bees failed by that small quantity to attain the point of the minimum. There is, however, no foundation for either supposition; the measurement of Maraldi is correct, as we have every reason to believe, and the bees have with rigorous accuracy solved the problem; for the error turns out to be in M. Kœnig's solution. The steps of his process are not given by M. Reaumur, nor am I aware where they are to be found. Possibly it is in the logarithms that he has, by neglecting some decimal places, gone wrong. This much is certain, that the true solution is not 109° 26′ and 70° 34′, but 109° 28′ and 70° 32′, exactly as M. Maraldi found the angles to be by his measurement. That there may be no doubt respecting this matter, Mr. Maclaurin's subsequent solution* having been geometrical, while M. Kœnig's is stated to have been by the differential calculus, I investigated the problem by that calculus in two several ways, and desired a learned and skilful mathematician† to investigate it in his own way, which turned out to be different from both mine. The result of the three methods was the same, and coincided not with M. Kœnig's result, but with M. Maraldi's measurement. It is also to be observed that, for the purpose of avoiding all doubt that might arise from the logarithms, one of my solutions is purposely addressed, not to the angles of the rhombus, but to the angle which is made by the planes of the two rhombuses, because, that being an angle of 120°, is found without any fraction or approximation. It may further be observed that the precise length of the perpendicular from the angle of the rhombus to the opposite side, that is, the breadth of the rhombus, being the side of the hexagon, as found in that solution, at once indicates the exact angles; for no other angle than 120°, formed by the two rhombuses inserted in a hexagonal prism, could give this exact breadth. This angle being a continuation of the hexagonal angle is a clear proof that the angles, as measured and actually made, are those given by the investigation; for no difference could on this part of the reasoning be introduced by the logarithmic approximations.

The construction of the cells, then, is demonstrated to be such that no other which could be conceived would take so little material and labour, to afford the same room. In order to ascertain how great a saving is effected by this construction, it is necessary to compare it with some other, and the one which most naturally suggests itself is that which of all others comes nearest to this, namely, the hexagonal prism terminating in a hexagonal bottom. For we have already seen that this is considerably more economical than the only other figures which fill up any given space, those whose sections are a square and an equilateral triangle. Compared then with such a prism, the cell which terminates in a pyramid whose angles are those formed by

* It is singular that so learned a mathematician as Dr. Reid should have given so erroneous an account of the history of this discovery. He describes Mr. Maclaurin as having resolved the problem "by a fluxionary calculation," in the *Philosophical Transactions*, whereas his investigation there is purely geometrical, and intended to show the power of the ancient analysis. Dr. Reid also represents him as having ascertained the angles "by the most exact mensuration the subject would admit," whereas the measurement had been made thirty years before, and was never repeated by him at all.—*Essays*, vol. iii.

† My worthy friend and neighbour, Mr. Slee, of Tirrell (Westmoreland), well known to those who pursue their studies at Cambridge.

the bees, effects a saving of surface equal to $\left(\frac{3\sqrt{6}-6}{\sqrt{8}}\right)s^2$ or $\frac{3}{2}\left(\sqrt{3}-\sqrt{2}\right)s^2$, s being equal to the side of the hexagon. The saving then is $\frac{12}{25}$ of s^2 nearly, and taking $s = 1{\cdot}387$ of a line is about $\frac{23}{25}$ of a line square, the whole surface of the bottom being about 8 square lines; taking the average of the working bees' cells $s = 1{\cdot}38$, (1·387), and the height $= 5$, the saving is ·91 square line upon a work of 8·1, or equal to between an eighth and a ninth of the work on the base; and on the whole work, (45·68), nearly $\frac{1}{50}$. But this is in truth (though coinciding exactly with the amount of saving deduced from Maclaurin's solution) much under the real saving effected upon the whole—for this supposes the length of the cell to be given, proceeds upon that, and only compares the saving upon the bottom of the cells. But as a certain length of cell is required for the bee, if the cells were not fitted into each other by the pyramidal form, but were opposite to each other, and joined by the common hexagonal plane, each cell must be lengthened by a line equal to the height of the apex of the pyramid above the plane of the hexagon; consequently the two opposite cells, or the whole prism composed of these cells, must be lengthened by the whole altitude of the pyramid, the whole surface of the bottom being nearly 12; and this will make the difference between the surface of each two cells having a common hexagonal bottom, and the surface of the two cells with pyramidal bottoms but fitting into each other and to a third cell, equal to $\frac{(3\sqrt{6}-1)}{\sqrt{8}}$ s^2; or 1·53 of s^2; and taking $s = 1{\cdot}38$ line as before, 2·94 square lines upon a work of about 85 square lines, supposing the length of the cell from the acute angle of the rhombus to be 5 lines, that is a saving of nearly one twenty-eighth on the whole of both sides of the comb. The saving of room in the hive by this shortening of the cells is also very considerable. It is equal to $\frac{s}{2\sqrt{2}}$ in each comb; if then there are ten combs it amounts to above $3\frac{1}{2}$ s, or if s be taken at 1·38, to above $4\frac{4}{5}$ lines; and if the depth of the cells is 5, to near a twentieth of the whole space occupied by the combs.

This saving is effected, however, not merely by the angles of the rhombus being of the size pointed out, but also by the fitting of the opposite cells. Part of the saving therefore is owing to this, and part owing to the minimum proportion of the angles of the rhombs. If they only have one of their diagonals equal to the diagonal of the hexagon ($\sqrt{3}$), they will fit each other and effect the saving in the length of the cell. But unless they also have the angles of a certain proportion, there may be a loss on the whole as compared with the hexagonal prism; and unless they be of the given proportion, there cannot be the greatest possible saving as compared with that prism.

The comparisons hitherto made have all proceeded upon the supposition that the cells must have not only a given capacity, but a given length. It is manifest that if they were only used for storing honey and bees' bread, the capacity alone would be material; the length is rendered material by the necessity of room being provided for the insect, and especially for the young bees. If the cells were not required to have more than a given capacity, a greater saving could be effected by a construction which should vary the proportions of their width and depth, leaving their capacity the same. By the same kind of investigation, which leads to ascertaining the form of the base most conducive to saving wax and labour, we find that the proportions between the hexagon's side and depth of the cells must be 2 to $\sqrt{2} + \sqrt{3}$, or about 2 to 3·14, the breadth and depth of the cells nearly equal, and the rhomboidal base cutting the plane of the walls at somewhat more than three-fourths from the open end. The saving effected by this construction as compared with the one actually employed by the bees, supposing still the sides of the hexagons actually made by them to be 1·387, and the depth 5 lines, would be 7·41 square lines upon a work of 38·28, or nearly a fifth of the work and wax, or if we include the outer base in both cases, the saving would be 3·8 upon 46·88, or above a twelfth upon a single cell.* If then the only object for which the cells are made, were the storing of bees' bread and honey, supposing that so shallow and wide a cell could equally serve these purposes with a deeper and narrower one, there would, *upon a single cell*, be a waste of

* M. L'Huillier (*Berlin Mem.*, 1781, p. 280) states that P. Boscovich's solution agrees with Maclaurin's in the *Philosophical Transactions*, 1743; and yet he seems never to have seen Maclaurin's; for he says, "All these mathematicians have considered this matter as beyond the powers of elementary geometry, and as requiring of necessity the application of the general principles of maximum and minimum founded on the differential calculus or on the limits of ratios;" and he seems to think himself the first who has shown that the problem could be resolved by elementary geometry, whereas Maclaurin's solution is by purely elementary geometry.

materials in the construction employed by the bees as compared with that which we are considering. But the objection is manifest to an arrangement which would make the whole weight of the fluid in the case of the honey, press upon so wide a surface as between 8 and 9 square lines of the wax with which the outer orifice is closed, instead of somewhat less than 5 square lines, the average size of the present orifice in the common cells. The film of wax now sufficient to contain the honey would no longer be enough, and a surface of 8½ lines at least would be required, which could probably not be applied after the cell had been filled with honey, certainly not unless the honey was extremely viscid. But the other use of the cell, and the more material one, of breeding, is also to be considered. The worm would be deposited in the large pyramidal base instead of the one adapted to its size, and when it grew there would be no room for the length of it, or of the pupa and bee after its transformation, the whole depth of the cell from the apex being only about 3½ lines. But there would be no support for it unless it moved out of the base on the side, and then it could only be supported in one angle of the prism, for it would be too small to fill the whole; so that the line which it would have for its length would be little more than two lines, while all the width of the cell would be lost. In this position the worm could not be reared, and it could never spin its cocoon. But it will be afterwards clearly shown that if the whole structure of the comb is considered, whatever may be the relative saving of wax and work upon a single cell by taking the greatest width and the depth nearly equal, as in the above construction, there would be a considerable loss upon the whole structure, and that the actual proportions adopted by the bee are more economical.

The saving of materials effected by giving the cells such a form as enables each wall and each base to serve for two cells is obviously the greatest saving of all; and we have already adverted to it. But doubts have been of late years entertained how far the walls and bottoms are common to more cells than one; this part of the subject therefore requires further illustration, before we proceed to consider upon what those doubts rest.

Suppose we take any number of equal hexagonal cells, whether terminating in pyramids or in the combs, or formed as hexagonal prisms, and place them round one cell so that their sides touch; and suppose we place in the like manner an equal number of such cells in a second set or tier, so that their bases touch those of the first tier—it is manifest that the number of bases required will be double that which would be required if the bases of one tier served for the cells of the other, and that double the number of walls will also be required if we only reckon those walls which touch each other. But as there are the outer walls of each tier to be added, the whole proportion of difference occasioned by the cells being separate, and having each its own walls, will not be that of 2 to 1. If there are 14 cells in all, that is 6 placed round one on each tier, or each face of the comb, then if the cells are separate there will be required 14 bottoms instead of 7, and 84 walls instead of 60, or in the proportion of 2 to 1 as to the bottoms, and 7 to 5 as to the walls. If instead of two sets, that is one set of 6 round a cell, there are any number n of sets, including the first cell as one set, then the number of walls saved on each tier (or face of the comb) will be equal to $9\ n^2 - 15\ n + 6$, and the expense of labour and materials occasioned by each cell having separate walls will be in the proportion of $2\ (3\ n^2 - 3\ n + 1)$ to $3\ n^2 - n$. Suppose the sides of the cells as before 1·387 line, their depth 8 lines, and that there is a square foot of comb; this will make the breadth of the cells about 2·77 lines, and n will be between 27 and 28; but take it at 28, the waste will be in the proportion of about 110 to 56, or somewhat less than 29 to 15 on the walls, and exactly 2 to 1 on the bottoms, and on the whole work about 51 to 26. The number of square inches of wax required for the comb, if each cell were separate, would be 3,115; if the walls and bottoms of one serve for those of the other, only 1,588 would be wanted; so that nearly double the amount of labour and materials would be required if the cells were separate, and had each a base and walls of its own. If the walls only of each cell are separate, and the bases are common to the opposite cells, the waste would be somewhat less in proportion, but would still be very great—it would be 1,366 square inches of wax upon a work of 1,428.

Now we must admit that this renders it extremely improbable that such should be the structure of the comb, especially when we perceive the extraordinary refinement of the contrivance resorted to by the bees for the purpose of effecting a much less considerable saving in the construction of the bases, a saving of only one-tenth of the whole labour and materials employed. Nevertheless, if the fact is otherwise, the argument from probability must of course go for nothing. Let us therefore now examine the fact.

The statement rests upon a paper of the late Dr. Barclay, of Edinburgh, published in the 'Transactions of the Wernerian Natural History Society' (vol. ii.) He sends to that body some pieces of honeycomb in which young bees had been reared, and observes, that the partitions between the cells at the sides and *base* are all double; that each cell is a distinct, separate, and "in some measure an independent structure agglutinated only to the neighbouring cells; and that when the agglutinating substance is destroyed, each cell may be entirely separated from the rest." He makes the same observation upon the cells of wasps, and adds, that the agglutinating substance is more easily destroyed in them. From a very allowable deference to the authority of this distinguished anatomist, and possibly from recollecting how much this branch of natural history owed to the discoveries of a great physiologist,* naturalists appear to have at once adopted his proposition, and they speak of it as "Dr. Barclay's discovery," without considering that it rests upon a single observation of one kind of cells, namely, those in which bees had been bred, and that it is wholly irreconcileable with the observations of Reaumur, Maraldi, and above all of Huber. That some had denied it, however, and upon this ground, appears from a note in Kirby and Spence ('Introduction to Entomology,' vol. i., p. 485), although those eminent naturalists, in the text both of that and other passages (as p. 502), lay down the position as admitted that the cells are double. Nothing, certainly, could be more unaccountable than that such a thing should have escaped the most laborious and accurate of observers, those illustrious foreigners whose names have just been mentioned. But that is not all; for if the position be true, the description of the process of the bees in making their cells, as given by Huber, must be wholly incorrect. The two accounts cannot possibly stand together. But there can be no doubt whatever that Dr. Barclay was misled by the cocoons of the chrysalis, the only cells which he examined having, by his own account, been those in which young bees had been hatched; and he having taken no step for ascertaining whether what he took for a second wall and base was made of wax or of silk. My reasons for stating this so confidently are as follows: but the experiments made and related hereafter complete the proof, and show how Dr. Barclay was deceived.

1. I have examined minutely a great number of combs with the help of powerful microscopes, as well as by the naked eye, and I never have been able to find the least appearance of a double wall, or double base. On the contrary, the sections of the wax, in what way soever they are made, plainly show that the plate is single in every instance. Combs have been thus examined of every kind, both those in which honey and bees' bread had been stored; those which were new made and had never received any stores; and those which having been filled with honey had been robbed by wasps. It was only cells where bees had been reared, and where the silk cocoon had been left,

* J. Hunter, Phil. Trans., 1792.

that presented anything like the appearance of a double plate. Nor can there be a doubt that this is always found in such cells. The exuviæ of the larvæ, with the filth, are well known to be always removed; but the silken lining spun by the larva previous to taking the chrysalis, still are expressly said by all naturalists* to be suffered to remain as strengthening the cell. They are not waxen of course, but silken, and form a lining to the waxen plates, assuming their shape exactly; and in old cells, where many successions of bees have been bred, the space is visibly contracted by the cocoons remaining; and these may be taken out, leaving the wax entire, with its plates all single. The cocoons come out of the shape of the cells.

2. I have communicated with other observers upon this subject, and having set them upon examining the facts, I find that none of them can discover for Dr. Barclay's hypothesis any other foundation than the conformity of the cocoon in shape with the wax plates.

3. Not only are the accounts given by former observers, as Reaumur, and especially Huber, quite inconsistent with the hypotheses of double walls; it seems hardly conceivable that these should be made of wax with agglutinating matter between the plates. The wax contains none of this matter in itself; and it is inconceivable that the bees should be able to insert it between the plates, as indeed it is that the bee should make two plates in the manner of its working, which consists either in first raising a thick wall and then drawing it out, or in placing new wax upon it, but in either case in scraping it thinner and polishing it, and making it plainer as well as thinner after it has been first raised. How could it get between the two plates to scrape and plane them? and yet it is not pretended that each plate is not as plane on one side as on the other—as plane on the side, which by the supposition is the inside, or the side covered by the other plate, as on the side exposed to the air, and to the scraping and polishing operation of the bee. As for the agglutinating material, either it may be in the silk, or it may be only the adhesion of that to the wax.

4. The examination of wasps' nests confirms the same opinion, and shows how Dr. Barclay has been misled. Indeed he has remarked, that in those nests the agglutinating material of which he speaks is less adhesive, and that the double walls are there more easily observed. If a wasp's comb, in which young have not been hatched, is examined, the cells will be found single like the bees' cells. But where the larvæ have spun their cocoons it is found that each cell has a lining. While recent, the lining is moist and can be more easily extracted;

* Reaumur, v. 600. Kirby and Spence, vol. ii., 197.

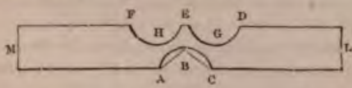
but even when dry it can be taken out. It is greyish or white, like fine cambric paper, and semi-transparent; the cell itself being brownish, like coarse paper, less tough than the white, but thicker and much more opaque. The white lining takes the hexagonal form of the cell exactly, and retains it if extracted when moist. The white cells thus formed by the cocoons which the larvæ spin are quite unconnected; and when removed leave the comb entire of brown paper hexagons. The walls of these cannot be split into two laminæ. But when they are lined with the white paper and you try to tear them asunder, you can easily do so; and the same wall appears so split in two; but one side only of the rent is brown, the other is white. So when the two papers adhere so closely that you cannot separate them entirely, some part of the white cell taken off will appear to be brown; but then there is a corresponding hole opposite in the brown cell from which it was taken, or if that cell is still lined with white paper, the white paper appears through it, at the vacancy where the brown was torn off. In short, nothing can be more clear than that the cells are originally made single, and that the apparently double wall is the lining of another material spun by the larvæ. It must, however, be observed that the economy of the material is not so great in the wasps' as in the bees' comb; the brown paper apparently being much more abundant than the wax, or we ought rather to say the material (filings of wood) from which it is made by the wasp being more easily procured than that from which wax is secreted by the bee (sugar). The hexagonal form is, therefore, chiefly important to save space and labour. The double wall would greatly increase the demand for the latter.

After all, it is possible that this white paper lining may be made by the wasp after the original brown cell has been formed. The necessity of economizing the material does not exist, and the labour of the wasp is much greater than that of the bee; for a single wasp makes the first portion of a comb without any assistance. It is impossible to compare the two kinds of paper together and not be satisfied that they are made by perfectly different processes. The brown may be made by kneading together the fragments of scraped wood and moistening them; but the perfectly uniform texture of the white plainly shows that it is the result of a secretion. No paper that we manufacture is more fine and perfect in its structure. It must have come from some pulp, the result of a chemical process and not of any mechanical operation, whether it be secreted in the body of the larva and spun by him, or secreted by the wasp and plastered upon the coarser brown material.

Having then ascertained the facts with respect to the form and position of the bees' cell, the nature and amount of the saving in room, in work, and in materials, which their structure effects, and the precise manner in which that saving is made by the structure, we proceed to inquire how the insect works in order to form it; and here several explanations that have been given, founded for the most part upon an erroneous conception of the facts, must be first of all considered.

1. Buffon's is the most superficial, and, we may add, the most absurd of these; it has been universally given up, and yet the mistake upon which it rests has been at the bottom of some later theories. This will oblige us to consider it more at large than its own merits would require. He supposes that the cells by pressing upon each other take the hexagonal form, in like manner as soap bubbles blown together in a heap are observed to do. That an *appearance* of hexagons would be exhibited by such bubbles from their apparent intersections is possible. No hexagonal prisms, however, are really so formed. But let us admit that he takes the bubbles only as a familiar illustration, and means to speak of a congeries of cylinders, if bubbles could be so blown; and let us also admit that he means to reason upon such cylinders disposed in sets, beginning with a set of six round one cylinder in their centre. This is the only way in which anything like the result could be obtained, and it is a perfectly gratuitous supposition; but let us grant it for argument's sake. Now, if the cylinders are so disposed, it is certain that the planes passing through their lines of contact will form hexagonal prisms; consequently it may be contended that if each cylinder is pressed upon those surrounding it, the curve surfaces will become planes, and hexagonal prisms be formed; and as of all the cylinders placed in juxtaposition each will be the centre of six others, it may be further said that the whole must become hexagonal prisms. But after making every such admission, there remain two requisities which cannot be admitted, because both are contrary to the facts. In order that the prisms may be thus formed there must be cylinders first formed touching each other, and then these must be pressed against one another so as to bring their sides into the form of planes instead of curve surfaces, and the pressure must be the same throughout the whole number, in order that all may be equally brought into the prismatic shape. But neither the separate existence of the cylinders, nor the pressure, exists at all in the structure of the comb. The cells are not first made cylindrical and then pressed together. They are seen by observers to be formed originally in planes, with the exception of the first excavation in the cake of wax, which is a cylindrical groove, and is immediately made plane. It is made plane, too, before any of the six opposed

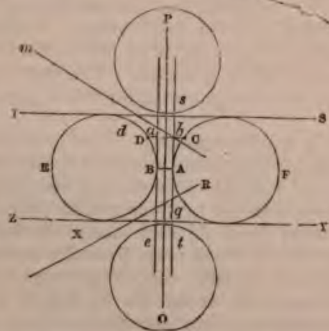
cells are formed, and when there are at the utmost only one on one side of the cake, and two on the other; but, in fact, the plane form is given to the curve surface when there are not three cylinders or parts of cylinders made contiguous to each other, but when there are three grooves in one cake of wax,



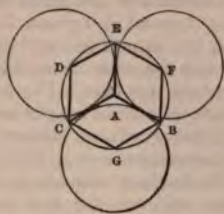
and the bees on the opposite sides are working at the grooves respectively. It is not that A B C, D G E, and E H F, are first made and press against each other at their lines of contact, but that in the cake L M there is a groove A B C made, and on the other side two grooves, D G E, E H F, and by eating away and plastering on C B A the planes C B and B A are formed on one side the cake, while by the like process on the other side, and, if not at the same time, immediately after, the opposite grooves D G E and E H F are made planes, and planes coinciding with C B and B A. Then these planes are not the six walls of the prism at all, but only the three rhomboidal bottoms; and upon the edges of those bottoms the walls are afterwards raised, and are plane from the very first, and perpendicular to the plane in which the cylindrical grooves are formed. Nothing, therefore, can be more unconnected with any curve surface than the walls are in every stage of their progress. The first requisite then is entirely wanting, that of separate cylinders to press against each other.

The pressure is equally wanting. That could only be given in one of two ways. Supposing, contrary to the fact, that there were a congeries of cylinders formed and touching each other, either these cylinders might by their gravity (which seems to be Buffon's hypothesis) press on each other, or the insect, by its growth or other efforts, might press from the inside of each cell. But the pressure of gravity, supposing there were no other objection to its operation, would not be equal; it would make the cells all of a different form according as they were lower or higher on the comb, while the upper ones of all sustaining no pressure would be cylindrical; besides that, a pressure sufficient to alter the form of the lower cylinders would be sufficient to tear the walls from the basis of the cells. The supposition of any expansion or motion of the insect, independent of other manifest objections, is precluded by the fact that the cells are as perfectly hexagonal in which no bees have been bred as those which have had young; and suppose it were admitted that the working bees could by internal exertion in the cells press them against each other, still this all rests upon a merely gratuitous assumption, verified by no observations, but contradicted by all observation; for no one ever has seen the cells in the supposed state of cylinders; on the contrary, all observers have found them in their progress of formation as prisms, and some have seen the very process of formation. Nothing therefore can be conceived more groundless than this hypothesis of pressure.

2. A much more ingenious and plausible theory has been in later times advanced, but founded in a great measure upon the same fallacy of supposing separate cylinders, although not upon the other fallacy respecting pressure. It is maintained with great ability in the article Bee, of the 'Penny Cyclopædia,' by a distinguished naturalist. It is supposed that the bee first makes cylindrical excavations, which are separated from each other at their contact by the thickness of the wall intended to be formed, and then cuts away so as to make the cylinders hexagonal prisms, the walls being of that thickness. Thus A F and B E being sections of two cells, which in their nearest parts are at the distance A B, the thickness of the intended wall; the bees are supposed to excavate in all parts of A C F and B D E, so much as always to leave a part *a b* equal to A B; and as the

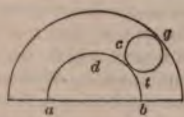


planes O P thus formed are tangents to the cylinders they will form hexagonal prisms. But an additional hypothesis is requisite for this theory; and accordingly it is supposed that the bee has a peculiar instinct, which impels it to excavate in the direction of A B and C D, but prevents it from ever going so far as not to leave the requisite thickness A B, *a b*. It is then said that this instinct, together with the fact gratuitously assumed of the excavations being at first cylindrical with spherical bottoms, will of necessity lead to the formation of hexagonal prisms, with pyramidal bases composed of three rhombuses; in proof of which the intersections are given of three circles with a fourth from the centre of which the tangents drawn to the points of contact of the other three will no doubt form three rhombuses with the lines drawn parallel to these tangents, as A G, A F, and



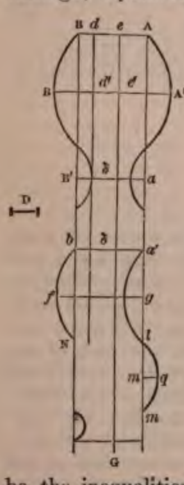
A D. A little examination will show the entire fallacy of all this in every particular.

The assumption of the peculiar instinct respecting the thickness of the wax is only gratuitous, and it cannot of course be disproved. But the assumption of the cylindrical excavations is contrary to the known facts. The groove, or fluting, first made in the cake is no doubt, at first, not only cylindrical in the direction transverse to the axis of the cake (that is, the direction across the cake), but also in the direction of the axis (that is,



along the cake, as at *c*); and if the excavation were made deep like the cell, walls as well as base, and in the form *a b d*, and the next cells in the form of *g*, there might be some ground for the hypothesis. But we know that the groove *a b d* is only made deep enough to form the base, and that its outline is changed into straight lines before any of the wall is raised, the walls of the cell being made, not, as the hypothesis assumes, by a cylindrical excavation, but by raising planes on the outline of the base. But admitting this excavation, contrary to the fact, the supposed instinct would not account for the formation of the plane sides out of the curve surfaces. If the bees excavate in the direction A B (p. 334), and then in lines parallel to that, supposing them to have found that line by the instinct showing them the thinnest place, they would go on till they got to S T, the tangent of the two circles on the one side, and to Y Z, the tangent on the other side, making a plane of the thickness A B, and of the length *t s*. But that is not what is wanted to make the side of a hexagonal prism; they must stop at *q* and at *b*, the points where the tangents M R and *m c* intersect the tangent O P. So that there must be another instinct, wholly unconnected with the thickness of the plate, to prevent them from carrying the working beyond a certain length. Nor can this difficulty be supplied by supposing two bees to work, one from the thinnest part B, and the other from the thinnest part *d*, for the cell can only contain one bee. The supposition then must be an instinct to work a certain length and in a certain direction; but that is, in other words, an instinct to work a hexagon, which, therefore, is assuming the very matter in question.

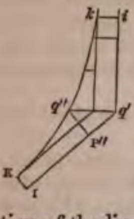
Nor is this all. The instinct respecting the thickness of the plate will not advance us even the first step, that is, the formation of the plane O P of parallel sides and equal thickness (the purpose of supposing it), unless at the same instant we suppose two bees at work, one in each cell, one working from A and C towards B and D, and another from B and D towards A and C; for if one bee only is at work from C towards D she will go through, beyond A, till she gets within less than the given distance A B of the surface at D, and consequently will make a curve surface, and not a plane. Indeed all the cakes on which the bees actually work are unequal, having on each side convexities, concavities, and planes; so that a section of the cake is as in figure, which represents all the possible combinations of those inequalities. If one bee works alone, D being the given distance or thickness at which the instinctive fear of perforating acts and stops the excavation, *d* B being taken equal to D, she would penetrate from A to *d*, and in like manner from A′ to *d*′, and from *a* to δ, B′ δ′, *b* δ &c. being always equal to D; consequently the line *d d*′ δ would be parallel to B B′ *b f* N, and no plane could be formed. The length of the lines A *d*, A′ *d*′, and δ *a* being by the hypothesis immaterial, the surface formed would therefore be parallel to the opposite side of the cake, whatever might be the inequalities on either side, and a plane surface could only be formed in the one case of the side B B′ *b* being itself a plane surface, in which case the instinct is not wanted,



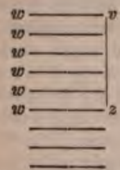
there being a plane surface formed already. The hypothesis must therefore be, that while one bee is working from A towards d, another is working from B to d; and that the instinct operating as soon as the one arrives at d and the other at e, each retreats and excavates in the next line parallel to A B or $a\ b$; A e being equal to $e\ d$ and each equal to $\frac{D}{2}$.

But the two working together could only form a plane in the case of the axis of the cake e G being the axis of the opposite surfaces; that is, in the case of the opposite sides A A′ a and B B′ b being exactly similar; for if they are not (which is the case in nature), in order to form a plane by the supposed instinctive fear of perforating, the bee working on the side A A′ a must work with the same velocity as the other from A to a'; with a smaller velocity from a to g, with a greater velocity from g to l, the velocity of the other bee being accelerated from b to f, and retarded from f to N; and these accelerations and retardations must vary according to the form of the two surfaces.

If, however, the cylindrical excavations are supposed to be perfectly smooth, and of equal curvature, still the two bees must work with exactly the same velocity in order to form a plane, and must begin working at the same instant; and must each have the same instinct of stopping at the same point (p. 334) q and b; and then a third bee must begin to work in the cylinder P s towards the tangent C m, and the bee in F R must work towards X q, while a fourth bee works in O t. Suppose it could be arranged among them that each should be ready to begin working in one line at the very moment the other had finished working on another, yet no bee ever works long on any part of the comb, but is relieved by a succession of workers; and therefore this succession must also be so arranged that each shall be relieved exactly at the time when a line has been finished, and before another is begun upon. Then suppose a bee comes to the point q where she is to stop, and begins on the other line q M; when she is in the angle at q, she must work through, and indeed all along the line q X, because at that point q she has opposed to her not the thickness of the wax bounded by the circle $e\ t$, but the whole wax from q along towards X. The supposed instinct therefore would never stop her in that direction, there being no vacant space nearer than the circle X M. Indeed the theory wholly fails to provide for the excavation of the six angles of each hexagon, for the bee must work in lines parallel to the shortest line I K, $i\ k$ (p. 338) which alone the supposed instinct shows her; that instinct giving her no other indication of any direction. When she comes to $q''\ q'$ therefore, or to $q'' p''$ and stops, she must go in the direction $q' i$, in lines $q'' q'$ or $q'' p''$ parallel to i K or I K respectively; and must therefore leave the wax in the space $q'' p'' q'$ untouched. This wax can only be excavated by changing the direction of the working; as either by changing from the parallel lines when the bee comes to q'' or by all along working in the direction of the radius of the cylinder, and not in parallel lines. But she can neither make that change, nor find the direction of the radius by merely knowing the direction of the lines I K, the thinnest part, and the supposed instinct shows her nothing beyond this line I K.



But again when we speak of the bees working towards one another in the lines A B, C D (p. 334), we are supposing them to excavate each with perfect equality, and to penetrate in that direction in precisely the same time. Now this implies that they must each not only work in the very direction to make them meet, but that each must remove the same mass of wax in the same time; that each must every instant take exactly equal particles of the wax away; and the whole hypothesis rests upon their working in lines w, w, till by meeting at the given distance they leave the plane of the given thickness; and not upon their ever clearing away the wax in the direction $v\ z$, after once reaching from w to v; for if they are to do so, they must be able to draw that line $v\ z$, and this requires another instinct to be supposed. Now the moving from w to v, and throwing back the particles excavated, and then going back again to w and so on again towards $v\ z$, is one of the most difficult operations that can be conceived, especially when it must be performed in exactly equal times by the bees on the opposite sides; and after they have gone through this operation along the whole line $w\ v$, only one layer is excavated, and the same operation has to be performed on the next, and so on until the whole depth of the cylinder is thus excavated. And if in the whole of these hundreds of perforations or punctures one bee makes one single movement different as to the time or the direction she takes from the movement made by the opposite bee, there will be an inequality, or a hole in the wall.



But lastly, how was the original cylinder formed which this theory assumes? Is it at all easier for the bee to make an exact cylinder with a smooth curve surface, than to make a hexagonal prism? Apparently not. Then why assume the bee to have the power of doing that without any peculiar instinct, and suppose the instinct about the fear of perforation, in order to explain the making of the plane sides of the hexagon? The theory clearly is defective on this if on no other ground, and it either supposes unnecessarily a principle not wanted for explaining the phenomena, or it leaves the phenomena unexplained for want of a necessary principle.

But if all that has been stated were left out of consideration as regards the hexagonal walls of the cells, the theory would still fail completely as to the rhomboidal bases. It is an entire fallacy to suppose that the intersections exist as in p. 335, even upon the hypothesis of cylinders, and it is an equal fallacy to suppose that, if they existed, they would form the three rhombuses as they are found in the comb. The circle from which these intersections are supposed to arise, is merely ideal; admitting the three cylinders to be exactly as given in the figure, the fourth circle cannot possibly be part of any cylinder; for none of the cylinders by the hypothesis intersects three others. But if it did, it would not make the rhombuses required. Three rhombuses are no doubt formed by the intersections of four circles, as described in the figure; but their angles are 120° and 60° respectively. Now the angles of the rhombuses in the comb are according to the measurement 109·28′ and 70·32′; and these are the angles given by the solution of the problem of *maxima* and *minima*, as has been already shown. The mistake of supposing that because three rhombuses are formed by the circles intersecting, therefore this hypothesis tallies with the construction of the bottoms of the cells, appears to have been the chief reason for adopting the theory; and yet it is clear that the entire difference of those rhombuses, and this difference too in the most artificial and singular part of the whole structure, at once shows the necessity of rejecting the hypothesis, supposing there had been no other proof of its inapplicability.

3. The attempts that have been made to explain the construction of the cells by a reference to the form of the insect's body are equally unsuccessful, and proceed, indeed, upon an obvious fallacy. For unless it can be shown that there are some parts of her body of the very size as well as shape of the hexagon and the rhombus, nay, unless it can be shown that these parts are placed at the same inclination to each other as the rhombuses are to the walls and to one another, the argument would not be at all advanced. The consideration of this will render it unnecessary to show in detail that the mere possession of the parts which the bee has, and with which she works as with tools, cannot enable her, without more, to form the cells.

Suppose then it were found that there is in some part of the bee a completely formed hexagon, but much smaller than the cell; and also in some other part a rhombus of the angles 109·28 and 70·32 respectively; but also much smaller than the plates of the base—First, how would this lead her to form either the walls or the base? There is no reason for her making them of those shapes, merely because she has the model in one part of her body, any more than of the shape of her other members. But next; supposing all her members were hexagonal or rhomboidal, why should she make the cell hexagonal and the base rhomboidal? Again; suppose that difficulty got over, why should she take any part of her body for a model? All these objections apply to her intention, her choice of the design. But there remains an equally insuperable objection as to her power of working, supposing her selection of the design to be made; for the having one of her parts hexagonal does not enable her to make a hexagon of a larger size. If an artificer has a model, he can only work according to it either by having acquired great skill from experience, and thus possessing a practised eye and the requisite sleight of hand—or by using instruments which enable him to follow the model without having so much practical skill of eye and hand; for some such skill he must have, even to follow a model by means of instruments. But the insect has no instruments; and even if we suppose that her limbs would turn out to be instruments did we thoroughly understand them, she still, without being taught, has the power of working by means of them to a model exactly as men learn by experience to do. But this is a violent supposition; for it is plain that she works without any instruments to guide her. Then granting her to have a hexagon and rhombus in her possession, nay, supposing them laid down before her, at the very least she is able to draw lines parallel to their sides. Now to do this with never-failing accuracy demands great skill, not much less than to make a hexagon and rhomb without any model at all.

It is, however, said that the bee may have not models merely in her own members, but tools which can at once make the angles required. This, if it be not another form of the same hypothesis, is certainly open to the same answer. For suppose we should find some limb of the insect having a part with an angle of 120, and others with angles of 109·28 and 70·32, which are the three angles formed in the cells; and suppose we get over the first difficulty as before—why should she use those parts in making angles, and not only so, but use the proper parts in making the proper angles in the cell and base severally? The natural tools might enable her to make the angles, but they never *could* enable her to make them at the proper places; that is, the angles of 120°, for example, at equal distances from the centre which she has not found, of a circle which she has not described, and also at equal distances from each other, or to join the angles by straight lines; that is, to continue the lines forming each angle and join them with the lines forming the two adjoining angles. In truth, no hypothesis of this description will account for the phenomena, unless it should be assumed, contrary to the known and manifest fact, that the insect has some limb of the size and shape of the whole cell, and is endowed with the power of forcing it into a cake of wax, or that the insect's body, when coiled, is of the size and shape of the cell, rhombus as well as hexagon, and has the power of so forcing itself into the wax. This would account for the form of the hollow, and then there would still be left to explain how she is enabled to place her limb or her body so as exactly to form the contiguous cells, leaving everywhere the same thickness of wall, and not only making the wall of each cell of the same thickness in all its parts by forcing in the precise direction required, but making all the walls of all the cells equally thick (which implies the having found the centres of the circles), and making all the cells of exactly the same depth; operations not much less difficult than forming the hexagon and rhombuses themselves without any model or tool. No such hypothesis, then, would advance the question, even if the facts bore it out, and if the bee was found not only to possess the form required, but actually to make the cells in the way supposed, and had some method hardly to be conceived of disposing of the wax forced out of its place, instead of working, as she does, by digging, scraping, and moulding. These facts, did they exist, would deserve our attention no doubt; but they would not explain the whole phenomena, nor would they deserve our attention more than the facts which are found to exist.

That no such facts exist as we have last supposed is admitted; but not even any of those first supposed exist, as limbs or other parts having the angles required. Mr. Huber examined all the parts of the insect with the utmost care, and could detect nothing of the kind. The teeth, feet, and antennæ, present no appearance of angles, and the head has an acute angle, which, supposing it to be that of the rhombus, would leave unexplained its obtuse angle as well as the angle of 120°, at which all the plates of the wall are inclined to each other and those of the base to the walls. But it is with the teeth, feet, and antennæ, that the insect is, by actual observation of the same naturalist, known to work; and these present no appearance even resembling any portion of the structure, though they are most curiously contrived for enabling the operation of moulding to be performed with delicacy. The antennæ, in particular, composed of twelve pieces, cylindrical, globular, and conical, are plainly so contrived as to have every possible flexibility, in order that they may move easily in all directions, being the feelers by which the work is guided, the sight of the insect not being used.

4. It was at one time supposed that the thickness of the walls was determined for the bee by that of the scales of wax which are secreted; and J. Hunter, finding that the thickness of the rhomboidal plates composing the base does not materially differ from that of the scales, concluded that those scales were used at once in the construction, and formed parts of the cell, as it were, ready made. But not to mention that the walls are less thick, Huber found that the bee works at the cell differently, and not at all by juxtaposition of scales; nay, that the wax of which the cells are made is a material different from that of the scales, having undergone a process which the bee is observed to perform, and offering results to chemical analysis, which the scales do not give, the latter being entirely and readily soluble, for example, in alcohol, whereas there are considerable parts of the wax altogether or all but insoluble. As for the shape of the laminæ which are secreted, it agrees with no part of the structure, being an irregular pentagon.

5. The discovery of Swammerdam, that the cornea of the bee's eyes is composed of hexagonal plates, or facettes, has been supposed by some to account for the form of the cells. But this is, if possible, a wilder hypothesis than any we have been considering. Indeed Swammerdam's answer to it is sufficient, that it might as well be supposed that men should build round houses because the pupil of the human eye is circular. In truth, the shape of these plates must be wholly unknown to the insect. They only transmit the light which is made to converge to a focus on the retina wholly independent of the form of the innumerable sides of the cornea; not to mention that the bee works in the dark by aid of the antennæ, and that if she did not, and if she saw the hexagonal form of the plates constantly before her, this, though it might suggest, as a model would, the form of the cell, could give her no kind of aid in making the wax of that figure.

All the theories to which we have been adverting admit the construction of the cells to be effectual for securing the saving of room and wax; and I am not aware that any one has ever denied this generally and absolutely. But some opinions have been given questioning the amount of the saving in the most extraordinary part of the structure, the form of the base, in so far at least as that concerns the wax. The advantages of this construction have not been denied; but it has been supposed to effect so little saving of wax that this could not be the purpose of the arrangement. Of those who have held this doctrine it is sufficient to specify M. L'Huillier as the person who has brought the most mathematical learning to the discussion of the subject.

In his paper already referred to ('Mém. Acad., Berlin,' 1781), after giving a geometrical investigation of the question of maxima and minima, he adds some general reflections; and though these are expressed with great doubt, and in language of becoming reverence, they certainly contain an indication that the author considered the saving of wax ascribed to the construction as a mistaken and fanciful view of the Final Cause, and as an abuse of that delicate speculation. For he thinks he has shown that only $\frac{1}{51}$ part of the wax is saved, and that one-ninth might have been saved if the dimensions of the cell had been those of what he terms the *minimum minimorum*, that is, if the proportions of depth and width had been such as to save most wax, among all the cells having the same form and containing the same space. He suggests, therefore, that this saving cannot be the object in view; but that there is either some other object, and he mentions none, or that this object of saving wax is modified by another, and he mentions as such the rearing of the young. As there can be no doubt that this latter view is the correct one, for the reason which I have assigned in treating of the amount of saving, there would have been no occasion to dwell further upon M. L'Huillier's doctrine, had it rested there. But he proceeds to say, that there is reason to suppose the saving of wax does not enter at all into the question, and that it may depend upon, or be a necessary consequence of the other arrangement, that, namely, for the care of the young. "On est même tenté de soupçonner que ce dernier (*i.e.* le bût d'économie) pourroit n'entrer pour rien dans la composition des alvéoles, lorsqu'on fait attention, qu'il peut être regardé comme une dépendance du premier, (*i.e.* le bût de l'emplacement des germes le plus sûr, et la propagation de l'espèce)." And he adds, that the solidity of the structure requiring the contiguous cells to leave no space unoccupied, and the opposite cells to fit into one another, this condition is "très-heureusement remplie par des prismes hexagonaux terminés par des fonds, tels que ceux que la théorie et l'observation s'accordent à peu pres à assigner aux alvéoles." (P. 292.)

If, however, any doubt remained with regard to the meaning and drift of these observations, and of the whole paper, it would be removed by the introductory matter prefixed, of which M. Castillon is the author, as he is of some admeasurements of the cells subjoined to the paper and forming its conclusion. M.

L'Huillier of course adopted this introduction, in which the purpose of his paper is set forth, and the accomplishment of that purpose described with some satisfaction. After a warm and just panegyric upon the doctrine of Final Causes, upon the services which it has rendered to Natural Religion, and upon Natural Religion itself, M. Castillon proceeds to lament that this doctrine has been abused, not only by writers who expressly treat of it, but by philosophers to whose physical inquiries the speculation is incidental. "Telle est notre foiblesse, nous abusons de tout. Nous tirons quelquefois de la riche mine des causes finales des décombres au lieu d'or. Notre esprit borné se laisse quelquefois éblouir par des fausses lueurs et croit voir des causes finales qui n'existent point." The example he gives is the Base of the Cells. "Par example, on a dit que le fond pyramidal qui termine les cellules des abeilles est destiné à procurer le maximum de l'épargne de la cire. Ceux qui ont avancé cette proposition ont-ils été guidés par la lumière ou par une fausse lueur?" His answer to this question is the 'Mémoire.' "C'est-ce que M. L'Huillier examine dans un mémoire qu'il m'a transmis pour être présenté à cette savante compagnie."—"J'y ai trouvé de belles recherches sur le minimum de surface des solides qui ont même capacité," &c. (P. 277.)

M. L'Huillier has *not* proved what M. Castillon and he suppose; and a little attention to the preceding statement of the former will show this. The supposed proof rests upon three grounds.—*First*, that the saving is only about $\frac{1}{51}$ of the wax employed.—*Secondly*, that a much greater saving might have been effected by another construction, had economy of wax been the object.—*Thirdly*, that the object is the solidity of the structure by the opposite cells fitting into each other, and leaving no intervals.

1. It is extremely erroneous to represent the saving as only $\frac{1}{51}$ part; for suppose we lay entirely out of view the shortening of the cells, and merely consider the saving of the rhomboidal base as compared with the hexagonal one, the proportion is that of $\frac{1}{2}\left(\sqrt{3}+\sqrt{2}\right) s^2$ to $\frac{2s^2}{\sqrt{2}}$ (the whole rhomboidal base composed of the three rhombuses and the six triangles, s being the hexagonal side), or as 1·12 to 1. There is about one-ninth part therefore saved of the wax required for making the base. The proportion of $\frac{1}{51}$ is obtained by comparing the saving upon the base with the whole wax of the cell, including the walls; and supposing the height of the wall to be to the sides of the hexagon as 5 to 1·387. But why is the wax of the wall to be imported into the calculation, with which it has nothing to do?

The question is between two forms of the bottom, not of the whole cell. Suppose two kinds of roof for a house were to be compared in order to choose the one that required least timber; though the house might be all made of wood we should only compare the expense of the roofs, and leave out the walls, which would be common to both plans; otherwise the relative amount of the saving would depend on the height of the house as well as the shape of the roof. This becomes the more evident in the case of the cells, from the circumstance of their depth varying in the same comb, and for the same kind of bee, according to many accidental circumstances, as the abundance of wax, the use to be made of the cell, the part of the comb where it is placed, and the obstacles in the way of the building; insomuch that I have seen in one comb cells ten and eleven lines in depth; others of the ordinary depth of working bee cells, five lines; and some hardly, if at all, deeper than the bottom, that is terminating nearly at where the rhomboidal plate begins. But in none of these various cells is any difference to be found in the proportions of the rhomboidal sides to the hexagonal side s, or in the depth of the bottom. The side of the hexagons is always the same for the same kind of bee; the depth of the pyramid is always $\frac{s}{\sqrt{2}}$, and the side of the rhombus $\frac{3\,s}{2\sqrt{2}}$. The saving therefore is somewhere about a ninth, and not somewhat less than a fifty-first part.

But there is another consideration which shows still more strikingly the fallacy of the argument derived from taking he whole walls of the cell into calculation. The thickness of the wax is very different in different parts of the cell, being much greater in the base, that is in the rhomboidal plates, and the part of the walls adjoining, the six small triangles, which are formed by a line drawn parallel to the base through the points where the rhomboidal plates cut the walls. This is manifest upon inspection; and I have tried it by weighing equal parts, in superficial extent, as far as it was possible, of the base and of the sides, and uniformly found the latter sensibly lighter. It did not seem that the proportion was always the same, but I never found the difference less than in the proportion of 3 to 2. The thickness of the walls varies much more than that of the base in different combs. But any considerable difference between the two portions at once destroys the argument of M. L'Huillier. If it is as 3 to 2, then the saving is nearly an eighth upon the thicker part, and consequently about $\frac{1}{33}$ instead of $\frac{1}{51}$ of the whole.

2. It is very inaccurate to say that because another form

would have saved more wax, if that had been the object, therefore it is not the object at all, as M. L'Huillier ultimately contends, after at first stating much less inaccurately, that the saving is one object subordinate to another. But even this is not altogether correct. It is an object, but taken in conjunction with another object; that is to say, the purpose is not to make the cell of a given capacity with the smallest quantity of wax, but of a given capacity and capable of holding insects of a given length and fluids of a given consistency and weight. It no more follows that saving of wax is not a part of the design because another object is accomplished at the same time, and which prevents the saving of wax being greater, than it follows that each of the two conditions in any question of maxima and minima is not attended to, because both are attended to. Thus, to take a very simple instance, if it is required to dispose a given surface in a rectangle so that both the sides taken together shall be the shortest possible; we know these must be equal, and the figure be a square. By making the figure twice as long as it is broad, the breadth would be saved, but the whole periphery would be much increased. Would anybody contend that no regard is paid to a saving of the breadth, merely because the saving of the length is also taken into the account?

But is it true that, supposing the object had been saving of wax alone, and the problem solved had no other condition to qualify that one, any other form would have more effectually accomplished the single purpose? We are of course always to assume that no interstices shall be left between the cells. If but a single cell is in question, there exists no dispute that another form would have given the same capacity with less surface than the hexagonal prism with a three-sided pyramidal base. But to state this is extremely superfluous, not to say puerile, and proves less than nothing; for if there is to be but one oblong cell, a cylinder would save most surface of all the regular oblong figures, and if it is not to be oblong, a sphere of all figures whatever would save most surface. Nor does M. L'Huillier's prism at all advance the argument; because, if he takes into the account the juxtaposition of the cells, he must also consider the opposite sides of the comb; and then he admits that his figure will not answer, for space would be lost and wax also.

But, suppose a cell must be chosen of the given shape, and which leaves no interstices, his argument is, that another proportion of the depth and width would have saved more wax. Now this, upon examination, turns out not to be true. We shall first suppose all the parts to be of equal thickness, and the walls no thinner than the base.

It is observable that he leaves entirely out of his computation the mouth of the cell and its hexagonal covering. He supposes the case of a cell open at that end and shaped according to his proportion, the length of the wall being to the width as 1 to $\sqrt{6}$ one way, and 1 to $\sqrt{8}$ the other; and he compares it with the cell actually made by the bees, also supposed to be open at the end. By thus leaving out the hexagon formed at the end or mouth of the cell, he makes it appear that there is a waste of wax in the cell made by the bees. But why is that hexagon to be left out? It is made of wax, like the rest of the cell; indeed, of thicker wax than the walls are made of. It is absolutely necessary for preserving the honey; and, if it is not required for the breeding-cells (which is by no means clear, for the grubs are covered over in general), still those could not, without deranging the whole structure of the comb, be of different dimensions from the cells used for storing honey, and without making it indeed necessary to have one comb for the one purpose, and another for the other, thus losing the great convenience of the cells being used indifferently for all purposes.

Now, taking the case of a single cell, it will be found that the solution of M. L'Huillier's problem gives a proportion by which, instead of any saving there is a loss, though to a trifling amount. The wax required for this construction exceeds that required in the cells actually formed by about $\frac{1}{15}$ of a square line, taking into the account the hexagonal plate required to close up the end of the cell. But, if this saving is trifling on one cell, it is very considerable indeed on the comb. In a hive of a cubic foot, the total loss would be nearly eighteen square feet of wax; because, instead of nine combs, with an interval of five lines between each, there must be $26\frac{4}{7}$ with the same interval. A waste, therefore, of between one-fifth and one-sixth of the whole wax required would be occasioned, instead of any saving. This, of course, supposes all the cells to be used for storing; but the argument applies, though in a diminished proportion, if we deduct the breeding cells.

The only reason that I can assign for M. L'Huillier having made this extraordinary omission of the hexagonal plate at the end or mouth of the cell is that, in the investigation of the problem originally proposed by Reaumur to Kœnig, that hexagon does not enter. But in that problem it could have no place. The side being a constant quantity, so is of course the hexagon. It would have dropt out of the differential equation, and could not affect the result required; namely, the value obtained for the side of the rhombus, or for its angles. But then, M. L'Huillier ought to have considered that it *did* enter into the investigation of *his* problem very materially; and, had he solved that problem by the calculus instead of geometrically, he would have found that the hexagon is not a constant quantity, and must have affected the result.

In truth, if the problem had been stated as it ought, it would have been this:—To find the proportions which would give the whole surface, of the cell (including the hexagon plate), a minimum. The result is not that of the wall, being $\frac{1}{\sqrt{2}}$ of the side or $\frac{1}{\sqrt{6}}$ and $\frac{1}{\sqrt{8}}$* of the width, but that of the wall being to the side as $\sqrt{2} + \sqrt{3}$ to 2, or the depth to the greatest width as 28 to 29 nearly; or (taking the solid content of the common bee's cell), instead of M. L'Huillier's proportion, of the depth to the greatest width as 2·53 to 4·75, it is that of 3·5 lines to 3·64. This is in reality the proportion in which, if the cell be constructed, there will be the greatest saving possible of wax and work—a saving on one cell of about 3·805 square lines, or nearly one-twelfth part—instead of a waste, as we have seen M. L'Huillier's proportion would occasion.

It may then be asked whether the argument of M. L'Huillier is not thus revived, though placed upon a new ground, and referred to the cell of these proportions now determined, and why those proportions do not justify the inference which he drew from his erroneous solution, and which that solution could not support? But the solution which I have given, though it proves a saving in a single cell, and though it shows a loss of much less than M. L'Huillier's, still leaves a loss upon the whole comb. A comb of a foot square made of cells, whose width was to their depth as in the above minimum ratio, would take about $\frac{1}{375}$ more wax than one whose cells were of the construction actually used by the bees; and there would be a waste of $\frac{1}{125}$ upon a hive of $15\frac{5}{8}$ combs, which would be the number required to give as many cells as nine combs of the ordinary structure. But it must further be considered that the wax of which the bottom is made being thicker than that of the walls, and the bottom bearing a smaller proportion to the walls in the cells of the form actually employed by the bees, than in the form which saves the greatest extent of surface, an additional saving is made by the proportions actually used.

This leads us to consider what form of cell will give the largest proportions of the walls, and the smallest of the rhom-

* According as the greater or lesser breadth of the hexagon is taken. The whole depth of cell is always $\frac{s}{2\sqrt{2}}$ more than the length of the wall; which seems to be overlooked by M. L'Huillier.

boidal base. This problem, like that of the minimum of surface, may be considered in two ways; first, as regards the angles of the rhombus; and next, as regards the proportion of the depth to the width of the cell, the angles of the rhombus being given. The second of these problems admits of no solution, there being no limit to the disproportion between the base and the walls, if no limits are assigned to the depth of the cell. But the first problem may be solved; and it gives clearly the hexagonal prism as the form in which the base bears the smallest proportion to the walls. But there would be an obvious disadvantage in this form; because a loss of surface would be occasioned by deviating from the angles which give the minimum of surface, and this would not be counterbalanced by the small saving in the proportion of the thicker parts of the work to the thinner.

There is, however, an important circumstance to be regarded, beside the extent of the plates and their thickness. The angles formed by the plates are apparently the most difficult part of the work; they appear to be laboured with the greatest care; and they are the parts where the wax is thickest—the solidity of the structure depending mainly on them. Now the saving of these solid angles becomes on this account very material, and we may inquire as before, first, what must be the angles of the rhombus in order to make the length of the solid, or dihedral, angles the smallest possible; and, secondly, supposing those angles to be given, what must be the proportion of the depth to the width of the cell, which makes the length of the solid angles the smallest. Both problems admit of a determinate solution. In the first it is found that the angles of the rhombus must be $109° 28'$ and $70° 32'$, being the same form which saves the most surface. In the second it is found that of all cells with such pyramidal base, that has the smallest length of solid angle in which the length of the wall is to the hexagon side as $\sqrt{2} + 1$ to 1, or the whole depth to the greatest width, as $5 + 2\sqrt{2}$, to $4\sqrt{2}$, that is as 39 to 28 nearly. But if we only regard the minimum of the solid angles of the base and walls without considering the angles at the hexagonal opening, then the form is that of the wall being to the hexagon side as 1 to $\sqrt{2}$, being M. L'Huillier's *minimum minimorum*.

From hence it is evident that this kind of fine and difficult workmanship is saved by the angles of the cell being such as they are rather than such as would effect the greatest saving in the proportion of the bottom, or thick plates, to the walls or thin plates. This, therefore, is an additional economy and an additional reason, beside those already given, against the form which gives that proportion as a minimum. But it also appears that retaining this form, the proportion of depth to width, which gives the minimum of solid angle, could only be adopted at an expense of surface. For if the angles round the hexagonal plate are left out of the consideration, then the form is such as has been already shown to lose somewhat upon a single cell, and upon the comb a great proportion; and if the angles round that plate are taken into consideration, though on a single cell there is a saving, there is a loss upon the whole comb, as compared with the common cell. All this is merely with regard to the saving of wax and work, supposing the breeding out of the question, and independent of the reasons against the shallower and wider cell derived from the form of the insect.

We may therefore conclude, from the fullest examination of the question, that it is an error to suppose any saving could be effected by varying the form of the cell in any of the ways proposed; and therefore that, supposing there were nothing taken into consideration except the economy of labour and materials, the form adopted by the insect is the most conducive of all possible forms to that object. It follows consequently that the position is wholly unsupported which represents this saving as not being one of the objects of the particular structure adopted.

3. The third ground of the doubt raised by the Berlin Academicians is founded upon the proposition that the object in view is the solidity of the structure, and that the saving of the wax is only incidental to this main object. The language used is not marked by the precision which might be expected in a mathematical discussion. After stating that the safety of the eggs and the process of breeding generally seems to be the object in view and not the saving of wax; it is added that the solidity of the structure so necessary for that object, appears to require that there should be no interstices between the cells, and that the opposite cells should, "*if possible*, fit into one another—conditions fulfilled by hexagonal prisms with bases, such as the theory and observation *nearly* agree in giving to the cells." The "nearly" is quite incorrect; there is an absolute and perfect agreement between the theory and the observation. But it is still more inaccurate to represent the actual structure of the prisms and base as necessary for the fulfilment of the conditions stated. Any hexagonal prism terminating in pyramids of three rhombuses would fulfil the conditions of leaving no interstices, and of having the opposite bases fitting into one another, whatever the angles of the rhombuses were. There is something, indeed, vague in the expression "conditions which are fulfilled;" and it may be said not to mean that the actual structure is the only one which fulfils those conditions. But *then if* that is not the meaning, the observation has no bearing

upon the question; for the purpose in hand is to show that the structure such as we find it to be, is intended to fulfil the condition of the cells fitting, and this can only be answered by proving that structure necessary to the cells fitting, which it plainly is not. This third ground, therefore, fails as signally as the others.

M. Castillon has recourse to an argument of a perfectly different kind with a view to displacing the doctrine upon this subject. He calls in question the facts. Father Boscovich had supposed that the admeasurement of the angles was too nice to be accurately performed, and that the coincidence of M. Maraldi's measures with the theory could only arise from his assuming that the angle of inclination of the rhomboidal plane was the same with that of the hexagon, viz., 120°, from which, no doubt, it would follow that the angles of the rhombuses should be 109·28 and 70·32 respectively. M. Castillon and M. L'Huillier seem to adopt this supposition with some alacrity, and the former adds some measurements of his own in confirmation of it.

Admitting the profound respect which is due to any opinion or even conjecture of so great a man as Father Boscovich, it must at the same time be remarked, that we cannot adopt his opinion without imputing a very great fault to another great man—Maraldi. If, instead of measuring the angles of the rhombuses, he supposed the other angles were the same with those of the hexagon, and then calculated the angles of the rhombus, and stated that he had found them to be so in fact, he unquestionably stated what was not true, and pretended to have made an experiment when he only made a supposition and deduced an estimate from it. If, indeed, he actually measured the angles which the rhombuses make with the sides or with one another, and found that angle to be the same with the angles of the hexagon (120°), he had a perfect right to state the angles of the rhombus to be 109·28 and 70·32, because that followed from his actual measurement of the other angle. But then that is just as good a measurement of the angles of the rhombus as if these angles had themselves been the subject of the observation; and no doubt this is an easier way of measuring the angles of the rhombus than a direct measurement of those angles. For take the two rhombuses which are a continuation of the dihedral angle of the prism and apply them to that angle, if the walls and the rhombuses accurately coincide, it shows the angles of inclination to be the same in the walls and in the rhombuses, and all the rest follows. Another measurement is also practicable without the operation, confessed to be of extreme nicety, of measuring the angles themselves of the rhombus. The breadth of these rhombuses—the line drawn from any part in one of the sides perpendicular to the opposite side—may be compared with the side of the hexagon; and if it is found equal to that side, all the rest follows; each rhombus makes with the other two and with the walls angles of 120°, and each rhombus has its two angles 109·28 and 70·32 respectively. This is the necessary consequence of the rhomboidal breadth being equal to the side of the hexagon. Now such a comparison is not very difficult to make, either by instruments or by placing the rhombuses over the walls, laying each, when separated, flat on a plane.

But M. Castillon's measurements, which are intended to confirm Father Boscovich's conjecture, and cast a doubt on Maraldi's statement, really deserve little attention, and yet they afford an unexpected confirmation of the latter, and not of the former.

They deserve little attention, because they are so few in number. There are five measurements of the whole depths of the cells; but that is immaterial to the question; and there are only two of the length of the longer solid angle of the prism as compared with that of its shorter solid angle. It does not appear that M. Castillon was aware of this proportion determining the angles; but he apparently gives his measures in order to show that they vary considerably, and that such observations cannot be relied upon. Now two such observations, differing from one another, would prove little or nothing; but it does so happen that one of the two agrees sufficiently well with Maraldi's. The first measures which he gives make the one length 4·622, and the other 4·144. Now the theory is not very different from this; for if the angles are as measured by Maraldi, and found by the calculations, supposing also the ordinary measure of the proportions between the width of the cells and length of the walls to be accurate, the proportion of the longer and shorter solid angle is that of 4·622 to 4·168, or within $\frac{1}{72}$ of a line, the same as M. Castillon found it to be.

The examination of the question into which we have been drawn has extended to a great length, and has been very minute; but it has not been superfluous, because the doubts raised by the Berlin Academicians have had considerable influence in shaking men's opinions upon the subject; and a disposition to suppose the whole doctrine respecting the structure of the cells erroneous, and the inferences connected with it fanciful, may be traced to the Memoir which we have been considering, although many who have treated the opinions of Maraldi and Reaumur as disproved by subsequent inquiry, have probably not looked at the work upon which this notion rests. The subject, too, is of the greatest importance; for it is by far the most remarkable, as it certainly is the most celebrated, of the operations of animal instinct; and if it had proved to be a mere groundless imagination, the whole of our opinions upon other less striking illustrations of the same views would have been very naturally unsettled. A full investigation, however, has proved to what the error must be ascribed, and has shown that the evidences of instinctive skill are in several material particulars even more remarkable than they had been before supposed to be.

We have hitherto been confining our attention to the structure of the cells as composed of wax, or wax and propolis, the only materials to which the attention of naturalists and mathematicians has been directed. As regards the cells only used for storing, there is no material except these employed. But the following observations and experiments seem to show that it is otherwise in breeding cells. It was the examination of these, with a view of satisfying myself as to the origin of Dr. Barclay's mistake, that led me to the more minute consideration of this subject, to which it is a matter of much regret that neither of those consummate observers, Reaumur and Huber, devoted sufficient attention. But it is to be hoped that others better qualified to continue their researches than I can pretend to be, will supply this defect; and it is with a view to excite their attention, rather than to aid their inquiries, that I venture to add the result of my very imperfect trials.

A portion of comb was selected, one part of which had never either been used for storing or for breeding, and the other had had a single brood. The former part was perfectly white; the latter slightly tinged with yellow or light brown, and in several places with the red streaks observed by Huber, and shown by him to be a vegetable matter collected from trees, particularly the poplar. The whole belonged to a comb made in a glass hive by a very late swarm about the middle of August, and taken soon after the middle of September. Indeed, that any young had been bred in it I should not have supposed, if the cocoons had not shown it—always supposing these to be the webs spun by the pupæ, according to the prevailing opinion, which is assumed in the remarks that follow to be correct, although some may possibly think that the full grown working bee has something more to do with the cocoons than is generally supposed.

The piece of comb was placed in alcohol, and no part of it much affected until heat was applied, when the white part speedily melted, and in part dissolved, no vestige of the form of a cell, or even a plate, remaining. A good deal of wax also ran melted from the other part, that in which bees had been bred; but it retained its form, and nearly its dimensions, notwithstanding the heat was continued for some time. When the spirit was boiled, the latter, or part of the comb in which bees had been bred, separated into parts; but even then it required being stirred to assist the separation and let the wax be completely melted. When another comb of an older hive was used, the separation was very much more difficult; but continued boiling in the alcohol, with stirring, effected it: and then each cell was found entire and apart from the others, and, when the liquor cooled, all were covered and filled with small wax globules, being that considerable portion of the wax which the alcohol does not take up. The same experiment may be made with boiling water, and the result is the same, only that the water takes up none of the wax at all. If spirit of turpentine is used, the experiment is more effectually and easily made, the wax being easily combined with the spirit; but this form of the experiment is not of course applicable where it is wished to ascertain in what part of the cell the wax is formed. Sulphuric ether crumbles down the wax, without dissolving any considerable part of it, and separates the cells after steeping some time. The experiment was then made with pieces of old comb, in which several broods of young had been reared The cells were somewhat smaller in width, the walls considerably thicker, and the colour much more dark, being a deep brown, in some places almost black.

The cells separated by these processes were now examined. Each was found to consist of a hexagonal prism, terminating in a pyramid of three equal rhombuses; in short, each cell had exactly the shape of the wax cells, but was formed of wholly different materials. The walls and base were made entirely of an extremely thin transparent or semi-transparent film, resembling gold-beater's leaf, but without a wrinkle. The old cells with thick walls kept the shape most distinctly. Indeed they had angles and planes as well defined as those of wax in the new comb. But they did not consist of a single film, like the cells where apparently only one brood had been raised; they had one film within another, and could be separated, so that as many as five or six could be extricated from the same cell; each of these had the hexagon form, and the first two, and sometimes three, had the rhomboidal form of the base also; but the innermost ones had the rhombuses less and less distinctly marked, till the last one or two of all had spherical, instead of pyramidal, bases. The hexagon's walls or the sides of the prism were in all distinctly marked. The bases were so much the less distinct after the first and second, in consequence of a much greater quantity of the red matter being placed in the base than in any part of the prism. In the prism it was generally traceable in the angles, as a kind of lining or coating, and not always continuous, for sometimes it was interrupted; and it seldom was of equal amount the whole length of the solid angle. Sometimes there was hardly any in these angles. In the base there was always a considerable quantity. The end or mouth of the cell was always edged round with a rim composed chiefly of this red matter, which I could not dissolve either in alcohol, spirit of turpentine, sulphuric ether, or caustic alkaline ley—whether these reagents were exhibited cold, and the cells with red matter macerated in them, or were heated even to boiling, and the cells with red matter stirred in them.

The *first* thing that was striking in these experiments was the closeness with which the film adhered to the wax. It defended it from the action of the solvents, and even for a time from that of the heat, at least it prevented the wax from melting for a considerable time; and it thus happened that long after the liquid had attained a temperature higher than that of melting wax the comb retained its form, and the cells continued to adhere.

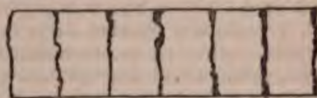
The *second* remarkable circumstance was the perfect stretching of the film all round the wax cell of which it had assumed the figure. There never was found the least wrinkle or laxity. Each film was tensely stretched in all its parts.

Thirdly. There was no interval whatever in any part. The whole of each cell was one entire piece of film, going all round the prism, and all through the pyramid, without any breach, and without any suture or joining. At first it seemed possible that the red matter might be a cement, or might cover the joinings, or conceal an interval; but on scraping it off, as well as examining parts where it never had been, this suspicion was ascertained to be groundless.

Fourthly. The red matter was not merely spread on the first or innermost cell, the one next the wax, but was by innumerable trials found to be indifferently applied to all the films, as well to the fifth and sixth as to the first and second.

Fifthly. The red matter always when examined appeared to be on the outside of the film; for there was constantly seen a film on the concave side between the eye and the red matter. It must therefore, have adhered to the film spun over it, and come off from the one it was plastered on.

Sixthly. The red matter, though very irregularly spread on the solid angles of the prism, and on the plates of the base, and on the upper part especially of the solid angles, that is, at the mouth, and near to and adjoining the dark coloured rim of the cell, seemed in any given cell to be at the same parts of each of the films which lined it. For when the side of a hexagon of many films was cut through, so as to stretch out the sides of the prism into one plane, the red matter was always observed in defined parts; showing that where it was wanting in one film, it was also wanting in the other six or seven. The appearance was of this kind when the rim was cut off at the one end and the rhomboidal base at the other.



The base seems on a superficial inspection an exception to this observation, inasmuch as in cells which have had many broods it is of a uniformly dark purple and almost black colour on the outside and perfectly opaque, while each of the films of which it is formed is transparent, except in certain parts, so that it might be supposed that the dark parts of one were opposite to the transparent parts of the others. But a closer examination shows that the red matter in these bases, as well as in the walls, is distributed in the same manner in each of those of which the whole mass is composed, and that it is the diminution of their size which causes the appearance just adverted to. Thus, the first, or innermost, the one next the wax, has a considerable space wholly free from red matter, but the dihedral angles are more or less lined with it, and the breadth of the red matter is greatest at the solid angle which the rhombuses make with the walls of the cell, and is very scanty indeed at the central trihedral angle made by the three rhombuses where it is probably not spread at all on the same side, but has the appearance of colour from the depth of that which is laid on the opposite sides. There is, however, a sensible proportional increase in the quantity of red in the smaller and innermost films. It probably increases gradually in each after the first or waxen cell. It tapers in this way. The other films are covered in the same places; but as the quantity of red matter does not diminish, but rather increases, the whole base is gradually contracted, till in the sixth or seventh there is hardly any transparent part at all. But it thus appears that the matter is applied nearly alike in each.

Seventhly. The films are quite unaffected by maceration, or even boiling in alcohol, oil of turpentine, ether, or caustic potash. But the red matter seems to be more or less dissolved in all these substances. By stirring in it, the dark coloured cells give to spirit of turpentine a light yellow or golden tinge. By longer maceration, and especially by boiling, alcohol and ether are likewise tinged, though not so deeply. It is probable that longer maceration and boiling in any of these liquids would dissolve the whole colouring matter of the red substance. Boiling in caustic potash converts it into a brown pigment, and seems to act upon the substance itself, as well as the colouring matter; but nothing affects the films.

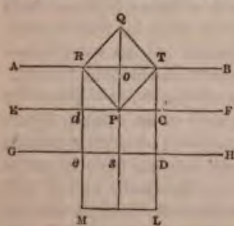
Lastly. A film of the same substance, transparent, but considerably thicker, was found to line the cell of the queen bee. The red matter here was more equally diffused over its surface in clouds and streaks, there being no angles at all to line with it. The film assumed the pear or flask-like shape of the wax; but a very remarkable fact was observed—the film was not always in the inside; it sometimes lay embedded in the wax, at least a layer of wax was laid over it of a sensible thickness, indeed considerably thicker than some plates of the common cell, and in one or two specimens it was much thicker. In case a thinner layer of wax might be in like manner spread on each film of the common cells as the red matter was, great pains were taken to ascertain this by examining the older cells, which had been separated by boiling in water so as not to dissolve the wax; and there seemed every reason for believing that no wax existed between the eye and the film, that is on the inside of the innermost film, in any but the cell of the queen bee. No queen bee's cell was observed to have more than a single film even in the oldest comb, where there were six and more successions of films in the other cells. But the examination of these large cells should be more fully gone into, and they should be compared as to their lining, with the cells, made out of three common ones when a queen is lost and her place supplied.

The formation of these films is plainly deserving of much greater attention than has ever been given to it. Neither the observations of Maraldi, nor those of Reaumur, nor even of Huber, are full and satisfactory upon this subject. They speak of the worm lining and carpeting the cell in spinning, or rather weaving, the cocoon, and yet they also speak of its enclosing itself in the cocoon, as if it spun and wove a web which covered its body, and in the inside of which it underwent its transformation. But in the meantime there are certain things established by the foregoing observations which seem to deserve attention.

The process must be conducted in one of two ways—either by the worm forming a cocoon round itself, and of an oblong figure inside sufficient to contain it when it changes its position from a coil perpendicular to the axis of the cell, into an oblong worm placed in the axis—or by the worm lining the walls of the cell, as Huber has in one or two places described it, though his description is imperfect, and he does not seem to have watched the whole operation. In the former case the cocoon, originally made somewhat of the shape of the worm, must afterwards be applied by it or by the chrysalis so as to line and adhere to the walls;—in the latter case the walls are lined at first by the act of the weaving or spinning. Let us observe the difficulties attending both these hypotheses, and the inferences to which they lead—inferences, in either case, as extraordinary, to say the least, as anything observed in the economy of this insect.

1. If the cocoon is formed loose and round, then when the transformation takes place the pupa must press against every part of the cell, so as to apply the film all round, and equally in every part. The wax may seize and retain the first film, which may be originally moist; or some propolis, being spread by the bees over the walls, may, with the agglutinating substance of the film itself, retain the film applied. That the immature animal itself should be able to do this is not more extraordinary than that it should be able to spin the film.

But the extraordinary part is the perfect adaptation of the cocoon to the cell. There is no wrinkle whatever; it fits exactly, in every part, both the planes and the dihedral angles and the trihedral angles. The extreme fineness of the texture may facilitate its fitting so many different shapes; but how is the size sufficient, and not at all more than sufficient, in any one place? Let us consider what the size must be in order to fit the different parts of the cell exactly. Take the base, and cut it by a plane at right angles to the axis of the cell, and passing through the acute angles of the rhombuses; this will cut off the pyramidal part of the base, and leave the rest of it composed of half the rhombuses and the six triangles. Then cut the prism by another plane parallel to the former, and passing through the obtuse angles of the rhombuses; and cut the prism by a third parallel plane, at the distance from the second of the altitude of the pyramid above the extremity of the prism; the three planes are equidistant, and cut the cell so as to leave three equal lengths. A B, E F, G H, being the three planes, and *o* P equal to the altitudes of the apex Q above B A, Q *s*, the axis, is divided into three equal parts by the planes A B and E F. Observe, then, the breadth which the cocoon must have in the length, Q *o*, from its termination in the bottom of the cell Q. The three intervals, or lengths, are in the common cell about one-tenth of the whole depth each. But the surfaces of the cell comprehended



between the planes are of very different extents. The *pyramidal* part, Q R T, is 3·03 square lines; the next part, T C P d R, is 5·05; and the hexagonal part, C D e d, is 4·04. Yet the cocoon must have been so spun as to have the size of the web vary in these proportions. For the first half line wound along its axis the web must have been made so as to have six breadths to one length, for the next half line ten breadths, and for the next half line eight breadths. Let any one consider what difficulty there would be in making a bag of cloth which should thus vary in its dimensions at different parts.

But that is the least part of the difficulty overcome by the bee; for the extent of the web which they make (that is, which their grubs make) in proportion to its length, does not vary at definite points; there are not, for example, two precise proportions, one for the part of the cocoon answering to the pyramid Q R T, and one for the part which is to line the other part of the base between the pyramid and the prism, T C P d R. The proportions vary at every one of the innumerable points between the apex of the pyramid and the obtuse angle P of the rhombs where the hexagonal prism begins. At each point beginning from the apex, there is an increase in the extent of web required until we reach the acute angles R and T of the rhombus. There is then an increase from the acute angle till we reach the obtuse angle P, when the extent of the web is the greatest; and during all the rest of the web, which is to line D e d C, its length round the hexagon remains the same, that is, all throughout the hexagonal prism. Moreover the increase does not take place equally; the periphery of the cell to be lined does not increase in the proportion of the distance of each ring or infinitely small section of the surface from the apex Q along the axis of the cell. From the apex Q to the acute angles T, R, the periphery increases at the distance along the axis from the apex (being equal to $6\sqrt{6}$ of that distance). But from the acute to the obtuse angle it increases much less rapidly, being equal to $3\,(4\sqrt{2} - 2\sqrt{6})$ of that distance along the axis, together with three times the longer diagonal of the rhombs; so that while the periphery is increasing fourfold from t, half the distance between the apex and acute angles to the acute angles, it is only increasing in the proportion of five to two in an equal distance from the acute to the obtuse angle, that is, from the point u in the axis corresponding with o, to a point on that axis corresponding with P.*

If we only consider what extreme complicacy and difficulty there would be in forming a cocoon which should thus increase at every hair'sbreadth, and increase in a ratio varying at different points, and should, on reaching its maximum size, continue afterwards stationary in dimensions, we shall be convinced how

* Neither t nor u can be seen in the figure, being in the axis.

insuperable the difficulties of the workmanship would be to any artist ever so expert or careful. But even this is not all—for as the web is to be afterwards, by the supposition, applied to the circumscribed walls, the extent of the curved surface of the

Fig. 3. *Fig. 4.* *Fig. 5.*

cocoon inscribed, must be less than that of the surface which it is afterwards to line, if that curve is wholly concave to the axis, in other words, if it have no points of contrary flexure. In order, therefore, that it may be exactly equal to the walls which it is to fit exactly, the cocoon must be of a form wholly different from that of the worm that made it. It must be concave at some points and convex at others to the worm; it must be loose and bag, as it were, and the progress of its bagging or being loose must vary at every point in order that, when applied to the walls, it may exactly fit them at every part, from the apex to the obtuse angles of the rhombus, and afterwards be uniform to the end of the prism. Instead of being as in figure 4, where the worm is represented under the bag by a vertical section, it must be as in figure 5, where the shaded parts represent the doubled parts answering to *a* and *b* of the transverse or horizontal section (fig. 3), the circle being thus the insect, and the line the web. The performance of such a work by the worm appears scarcely conceivable. Astonishing as the known and ascertained works of the perfect insect are, this would surpass them in a proportion that might almost be called infinite.

2. These considerations, and the observations of naturalists, as far as they go, lead us to adopt, almost of necessity, the

second inference, that the worm applies the cocoon as it is made directly to the walls. In this case we get rid entirely of the former difficulty, for the operation is certainly much more easy of forming the film upon the walls. That it is executed with perfect nicety and precision, is, however, no less true. There is never a break to be found, and there is no part thicker than the rest; so that but one layer is applied everywhere; and the worm knows so accurately where it has begun as always to leave off on coming round to that point, without ever going again over the same ground for half a hair'sbreadth. The material is also very remarkable. A very high magnifying power shows no threads, or separate pieces of any kind; in the great bulk of the texture it is for the most part solid and perfectly transparent. There are interspersed irregularly a few fibres, but it should seem as if the whole was a mucilage spread over the walls, rather then any web woven of threads. But though the difficulties attending the other theory are not found in this, it has difficulties of a different kind and exceedingly startling.

The first that strikes us immediately is the use of the cocoon formed on the waxen walls. The cell was already made, and of the required form and dimensions, in which the worm could be lodged, and grow, and undergo its transformation to the chrysalis, or from the chrysalis to the bee. How was the lining it with the film to assist the process? If the cocoon had been of another form, and wrapt round the worm, it might have served some such purpose of covering or support as cocoons generally do to the worm, and afterwards to the pupa; but here the cocoon exactly fits the cell, and in nowise alters its form; and by only an exceedingly small quantity its capacity. Still it is possible that the film may better suit the worm than the walls, or rather may better suit the worm when grown, and the chrysalis, for the worm was on the bare wax during the first ten or twelve days, and until it made the cocoon. But then, how are the second, and the subsequent cocoons, to be accounted for? The cell had been lined already completely with film, and the additional lining could add nothing to the advantage, whatever it was, which the first lining gave the worm and the chrysalis. If two linings were necessary for the second worm and pupa, how did the first do with one? and so of the third and all the subsequent broods. Indeed, when many come to be accumulated, there is a positive detriment occasioned by the cells being contracted.

Now this difficulty cannot be got over by saying that the same kind of anomaly occurs in other cases; for it will be found that there has as yet been observed no second instance of it, and that the resemblances are wholly imaginary. The only appearance of anything like this operation is in those cases where an instinct manifestly given for the accomplishment of certain purposes, leads to acts which are fruitless in consequence of some apparent mistake on the part of the animal; as where the fly, mistaking the flower for carrion, lays its eggs in the folds of the calyx whose smell had attracted it. But the case in hand is very different; for we have here not an accidental, but a constant and regular action of the insect, and in the great majority of cases, with a total failure, nay rather with inconvenient results. For one film or cocoon that is spun to serve the purpose of shielding the grub from the wax of the cell, five or six are spun one within the other to no kind of purpose, but rather to the loss of space, and yet the instinct which leads to this operation, is that of saving wax and work, because it is that instinct which makes the bees always prefer breeding in combs already used, and therefore lined with film wherever a brood has been, to building new combs of virgin wax. Even if we suppose there were only two broods on an average in each cell, which is certainly much below the truth, the instinctive operation would be misplaced, and fail as often as it succeeded. This is assuredly a strange kind of instinct, considering that certainty, almost infallibility, is the characteristic of the operation in all other cases, and that wherever a failure is found, there seems an exception to an otherwise general rule. No other operation of any animal can be cited which fails as a general fact, either oftener than it succeeds, or even as often. To make the thing still more extraordinary, the fact is observed in the operations of an animal the model of perfection beyond all others in its instinctive faculties.

We are thus driven to the conclusion that some hidden use exists to which the cocoon is subservient. When the queen bee finds a worm or an egg in any cell, she never lays another egg there. When the nursing bees find liquor deposited in the bottom round the egg, they pour in no more. Why should the worm make a cocoon when it finds the cell already lined with film? Nor can any distinction be taken between the work and the faculties of the worm and those of the grown insect; first, because the worm, on any supposition, is endowed with perfect instinct; and, next, because the adult bee aids in the operation by lining the angles of the hexagon with the red matter, and does so each time a film is spun. This difficulty is at once got over if we suppose that, like other grubs, it spins the cocoon round itself as a covering, and separate from the walls of the cell. But then we get into all the extreme difficulties pointed out already as to the spinning a loose web which *shall fit* every part of the cavity without a blank or a wrinkle.

There seems then no way of avoiding both difficulties, except by supposing that new made film has qualities different from old, and that these are in some way genial to the worm and the chrysalis. This is barely supposable. We cannot suppose that a contact with the red matter is necessary for the growth of the grub; for that matter being deposited on the inside of the earlier film, and adhering to the subsequent film, seems to coat its outside, but in fact never can be in contact with either the worm or the chrysalis, inasmuch as it never is laid on before the bee is fully formed, and has left the cell. The supposition now made of the peculiar qualities of new film is no doubt gratuitous, but there seems no other escape from the pressure of the difficulty with which the facts surround us.

The attention which has been paid at various times to the structure and habits of the bee is one of the most remarkable circumstances in the history of science. The ancients studied it with unusual minuteness, although being, generally speaking, indifferent observers of fact, they made but little progress in discovering the singular economy of this insect. Of the observations of Aristomachus, who spent sixty years, it is said, in studying the subject, we know nothing, nor of those which were made by Philissus, who passed his life in the woods for the purpose of examining this insect's habits; but Pliny informs us that both of them wrote works upon it. Aristotle's three chapters on bees and wasps* contain little more than the ordinary observations, mixed up with an unusual portion of vulgar and even gross errors. How much he attended to the subject is, however, manifest from the extent of the first of these chapters, which is of great length. Some mathematical writers, particularly Pappus, studied the form of the cells, and established one or two of the fundamental propositions respecting the economy of labour and wax resulting from the plan of the structure.

The application of modern naturalists to the inquiry is to be dated from the beginning of the eighteenth century, when Maraldi examined it with his accustomed care, and Reaumur afterwards, as we have seen, carried his investigations much farther. The interest of the subject seemed to increase with the progress made in these inquiries; and about the year 1765 a society was formed at Little Bautzen, in Upper Lusatia, whose sole object was the study of bees. It was formed under the patronage of the Elector of Saxony. The celebrated Schirach was one of its original members; and soon after its establish-

* Hist. An., lib. ix., cap. 40, 41, 42.

ment he made his famous discovery of the power which the bees have to supply the loss of their queen by forming a large cell out of three common ones, and feeding the grub of a worker upon royal jelly; a discovery so startling to naturalists, that Bonnet, in 1769, earnestly urged the Society not to lower its credit by countenancing such a wild error, which he regarded as repugnant to all we know of the habits of insects; admitting, however, that he should not be so incredulous of any observations tending to prove the propagation of the race by the queen bee without any co-operation of a male,* a notion since shown by Huber to be wholly chimerical. In 1771 a second institution, with the same limited object, was founded at Lauter, under the Elector Palatine's patronage, and of this Riem, scarcely less known in this branch of science than Schirach, was a member.

The greatest progress, however, was afterwards made by Huber, whose discoveries, especially of the queen bee's mode of impregnation, the slaughter of the drones or males, and the mode of working, have justly gained him a very high place among naturalists. Nor are his discoveries of the secretion of wax from saccharine matter, the nature of propolis, and the preparation of wax for building, to be reckoned less important. To these truths the way had been led by John Hunter, whose vigorous and original genius never was directed to the cultivation of any subject without reaping a harvest of discovery. Since the time of Hunter and Huber no progress has been made in this branch of knowledge. For we have shown that the supposed discovery of Barclay is wholly without foundation; and the attempts made by some mathematical reasoners to cast doubt upon the result of former investigations have been also proved to be signal failures.

* Œuvres, x., 100, 104.

ANALYTICAL VIEW

OF THE

RESEARCHES ON FOSSIL OSTEOLOGY,

AND

THEIR APPLICATION TO NATURAL THEOLOGY.

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FOSSIL OSTEOLOGY.

THE great work of Cuvier stands among those rare monuments of human genius and labour, of which each department of exertion can scarcely ever furnish more than one, eminent therefore above all the other efforts made in the same kind. In the stricter sciences the 'Principia' of Newton, and in later times its continuation and extension in La Place's 'Mécanique Céleste,'—in intellectual philosophy, Locke's celebrated work,—in oratory, Demosthenes,—in poetry, Homer,*—leave all competitors behind by the common consent of mankind; and Cuvier's 'Researches on Fossil Osteology' will probably be reckoned to prefer an equal claim to distinction among the works on Comparative Anatomy. That this great performance deserves to be attentively studied there can be no doubt. But as its bulk, in seven quarto volumes, may be apt to scare many readers, there may be some use in giving a general account of the progress of the author's inquiries, and of

* If English law were not a local learning merely, Fearne's work on Contingent Remainders would perhaps deserve to be thus ranked. In the eloquence of the pulpit, Hall comes nearer Massillon than either Cicero does, or Æschines, to Demosthenes.

the principal results to which they led him, and more particularly in showing their application to Natural Theology.

Long before his attention was called to the remains of animals found in various strata of the earth, in more superficial situations, in crevices of rocks, and in caves, he had, fortunately for science, been a skilful proficient in anatomy, both human and comparative. But the first steps of his inquiries concerning those fossil remains showed him how much he had yet to do before he could implicitly trust the received accounts of the animal structures. As regards the human subject, for obvious reasons, the knowledge possessed, and which the ordinary works of anatomy contain, is accurate enough and sufficiently minute. But it is far otherwise with the structure of other animals, and especially as regards their Osteology. Of this Cuvier found so many instances, that he began his investigations with examining minutely and thoroughly the bones of all those species which, or the resemblance of which, are supposed to have furnished the materials of the great deposits of fossil bones so abundant in almost every part of our globe. This, then, was the course which he invariably pursued; and he never attempted to draw any inferences respecting the fossil animal, until he had accurately ascertained the whole Osteology of the living species. There was obviously no other way of excluding mere fancy and gratuitous assumption from the inquiry, and making the science, of which he was really to lay the very foundation, one of pure reasoning from actual observation, in other words, one of strict induction.

In the course of his work there are to be found striking examples of the mistakes into which former inquirers had been led by neglecting this precaution. Partly by relying on incorrect, though generally received, descriptions,—partly by undervaluing the *requisite* comparisons of the fossil with the known bones,—partly, no doubt, by giving loose to fancy, observing the remains discovered with the bias of a preconceived opinion, and making the fact bend to a theory—authors had committed the most grievous errors, hastened to conclusions wholly unwarranted by the facts, and often drawn inferences which the facts themselves negatived instead of supporting. Thus M. Faujas de St. Fond, a geologist of great learning and experience, but who had upon a very scanty foundation erected a dogma, that all the fossil remains belonging to animals still found alive in different parts of the earth, and set himself to deny the novelty of all the fossil species of unknown animals, conceived that he had at length himself found among those remains two animals which, if they still existed at all, could only be found in the interior and remote parts of India. Of these supposed discoveries he published the drawings, representing two fossil heads. But Cuvier, upon examination, found one of them to be exactly the auroch or bison, and the other the common ox.* A more skilful naturalist, Daubenton, describes three sets of fossil teeth, in the King of France's cabinet, as belonging to the hippopotamus; and upon examination two of these sets are found to be teeth of two new and unknown animals,† and the third alone those of the river horse; and Camper, one of the greatest anatomists of his age, fell into a similar error. Upon the discovery of some fossil bones in the Duchy of Gotha, there was a general belief that they were some *lusus naturæ*, and several medical men wrote tracts to prove it. But a nearer inspection proved them to be elephant's bones.‡ The town of Lucern took in earlier times for the supporters to its arms a giant, from the opinion pronounced by a very celebrated physician (Felix Plata), that the bones discovered in that canton were human and gigantic, though Blumenbach afterwards examined

* Recherches, vol. iv., p. 108. † Ib., vol. i., p. 305.
‡ Ib., p. 120.

them, and found they belonged to the elephant. Finally, Scheutzer maintained that there were remains in different places of men who had perished in the general deluge, and supported his opinion by several instances to which he referred. Upon examination these have proved to be none of them human bones; but one set are those of a water salamander, while another belong to a newly discovered animal still less resembling our species, being something between a lizard and a fish.* When professional anatomists and professed naturalists could fall into such mistakes as these, there is little wonder that a statesman like Mr. Jefferson, however illustrious for higher qualities, should commit a similar blunder. He drew from the fossil-bones discovered by General Washington near his seat in Virginia, and to which his attention was directed by that great man, the conclusion that they belonged to an enormous carnivorous animal, which he named the Megalonyx. Cuvier, from a more correct examination, showed the creature to have been a sloth of large dimensions, and which fed wholly upon the roots of plants.

If these examples, and they might be very greatly multiplied, evince the necessity of a cautious examination, and of a previous attention to the Osteology of animals with which we are fully acquainted, the success of Cuvier's inquiries also shows that, with due care and circumspection, the reward of the inquirer is sure. The connexion between the different parts of the animal frame is so fixed and certain, and the species run so little into one another, that it requires but a small portion of any animal's remains to indicate its nature, and ascertain the class to which it belongs. Each small portion, so it be superficial, of bone—each little bony eminence—has its distinctive character in each species; and from one of these, or sometimes from a piece of horn, or of hoof, or a tooth, the whole animal may be

* Recherches, vol. v., pp. 433 and 451.

determined. "If," says Cuvier, "you have but the extremity of a bone well preserved, you may by attention, consideration, and the aid of the resources which analogy furnishes to skill, determine all the rest quite as well as if you had the entire skeleton submitted to you."* Before placing entire reliance on such an induction, this great observer tried many experiments on fragments of the bones of known animals, and with a success so unvaried as gave him naturally implicit confidence in his method when he came to examine Fossil Remains.

Among those he discovered a number of animals wholly unknown, and of which no individuals have existed since the period when the authentic history of our globe and its inhabitants has been recorded. Out of the 150 which he investigated about 90 were either of new orders, or of new genera, or new species of genera still living on the earth. Consider, in respect to genera, there were in the 49 unknown species, 27 which belonged to unknown genera, and these genera amounted to seven. Of the remaining 22, 16 belonged to known genera, or sub-genera; the total number of genera and sub-genera, to which he could reduce the whole of his fossil species, known or unknown, being 36. It must, however, be added, that it is very possible the remaining 60 also may be of new species; for as he only had the bones to examine, it does by no means follow that the living animal did not differ as much from the ones which have the same Osteology, as the mule, or the ass, or the zebra do from the horse, the jackall from the dog, or the wolf from the fox; for the skeletons of a zebra, an ass, and a horse, present the same appearance to the osteologist; so do those of the jackall, the dog, the fox, and the wolf; and yet the same bones clothed with muscle, cartilage, skin, and hair, are both to the common observer and to the naturalist

* *Recherches*, vol. i., p. 52.—We have used the expression skeleton; the author says animal, but manifestly, from what follows, this is incorrect.

animals of a different species or subdivision. This consideration is to be taken into the account as a deduction or abatement from the certainty which attends these researches; the certainty is only within certain limits; the fossil animals which now appear to resemble one another, because their Osteology is the same, may have differed widely when living; those which appear to have been of the same class with other animals that yet people the earth, may yet have been extremely different; and those which now seem to be in certain particulars different from any we or our predecessors have ever known, may differ from all that live or have lived on the earth we now inhabit, in many particulars far more striking than the varieties which their bony remains present to the osteologist's eye.*

The situations in which those remains were found, and are still to be met with in greater or less abundance, are various; but they may be reduced to three classes in one respect and to four in another: to three, if we regard only the kind of place where the bones are collected and found, in other words, their mineral matrix; to four, if we regard the periods at which the earthy formations were effected, and the bones of animals living then, or immediately before, were deposited. In the former point of view, the remains are found either, *first*, imbedded in strata, at greater or less depth, and of various kinds, and at various inclinations;—or, *secondly*, mixed together, and with earthy matter, in caves, and in rents or fissures or breaches formed in rocks;—or, *thirdly*, scattered more sparingly, and as it were solitarily in alluvial soil or superficial detritus, in portions of the earth, apparently while it wore its present form, and was peopled by all or most of its present inhabitants. In the latter, and the more important point of view, those remains are either found, *first*, in the beds which were deposited by the

* Mr. C. once or twice adverts to this consideration; but he certainly does *not bring* it so prominently forward as would have been desirable.

waters of a world before the existence of either human beings or the greater number of living genera of animals—as in the copper slate of Thuringia, the lias of England, the clay of Honfleur, and the chalk—in these strata the remains of reptiles are found with extinct species of marine shells, but no vertebrated animal higher than fishes; or, *secondly*, in the strata deposited by the sea, after it had destroyed the first races, and covered the land they lived upon,—and in these beds, which at Paris lie on the chalk, are to be found only animals now extinct, and of which most of the genera and all the species differ from any we now see;—or, *thirdly*, in the strata deposited by the sea, or in fresh water lakes,—and in these later tertiary beds are to be found animals now unknown, but resembling the present races, being different species of the same genera, or apparently of families still living, but not now inhabiting the same countries, or living under the same climates;—or, *fourthly*, in places where rivers, lakes, morasses, turf-bogs, have buried the remains of existing species; and as these changes of a limited extent have happened to the globe, constituted as it still is, those animals appear to have been for the most part identical with the animals which we still see alive in various parts of the world, at least as far as their skeletons can tell.

Paris is the centre of a most extraordinary geological district. It is a basin of twenty leagues, between fifty and sixty English miles, in diameter, extending in a very irregular form from the Oise near Compiegne on the north, to the Canal de Lory, beyond Fontainebleau on the south, and from Mantes on the Seine upon the west, to Montmirail on the east; comprehending within its circuit the towns of Paris, Versailles, Fontainebleau, Estampes, Meaux, Melun, Senlis, Nangis, and coming close to Soissons, Gisors, Beauvais, Montereau on the Yonne, Nogent on the Seine, and Condé; but not being continuous within these limits, for it is frequently cut off in islands, and everywhere towards the outline deeply indented with bays. This vast basin consists of six different formations, in part calcareous, but in some of which gypsum is so plentiful, that the quarries dug in it go by the common name of the Plaster of Paris quarries, and indeed gypsum has derived its common name from these. The lowest bed upon the chalk is composed of plastic clay, and it has covered both the plains and the caves of the district. This bed is full of fossil remains, very many of them belonging to unknown animals, and it also contains fragments of rock, which have come from a great distance. Above this bed is a layer of gritty limestone and shelly grit, of salt-water formation. Then come in succession siliceous limestone, fresh water gypsum, and sand and grit without shells. The fourth formation is sandy, and of marine origin. The fifth has fresh water remains and animals. The disposition of the land around and forming this basin wears in all respects the appearance of having been broken in upon and hollowed out by a prodigious irruption of water from the south-east. Considerable corrections have since been made, especially as regards the second and third of these formations of Cuvier.

It appears that the base or bottom of the Paris Basin must have been originally covered with the sea. Different parts of the ground were then covered with fresh water lakes, from which gypsum and marl were deposited, filled with the bones of animals that lived on their banks or in their islands, and died in the course of nature. After this deposition, the sea again occupied the ground, and deposited sand mixed with shells; and when it left the land dry for the last time, there were for a long while ponds and marshes over the greater part of the surface, which thus became covered with strata containing fresh water shells, the base of those strata consisting of a peculiar stone found in fresh water, and occurring in many parts of France. The *fossil* remains in this great basin exhibit little variety of families; and the vegetable remains show that the plants were confined to palms and a few others now unknown in Europe. As the great continents, which offer a free communication throughout, are inhabited by a great variety of animals, while New Holland and the other islands in the South Seas have only a very few, and these almost all of the same family, we may conclude that the land forming the Paris Basin was originally surrounded by the sea.

The deposits in the rents or fissures of the strata may now be briefly mentioned, and they present a very singular subject of contemplation. They are found all around the Mediterranean, at Gibraltar, Cette, Antibes, Nice, Pisa; in Sicily, Sardinia, and Corsica; at the extremity of the kingdom of Naples; on the coast of Dalmatia; and in the island of Cerigo. The body of the deposit is calcareous, and of the same kind in all these gaps or fissures. The same, or nearly the same, bones are everywhere found imbedded in it; they are chiefly the bones of ruminating animals; and beside those of oxen and deer, there are found those of rodents, a kind of tortoise, and two carnivorous animals. In these fissures there are many land but no sea shells; and the matter that fills them is unconnected with other strata. It follows from the first fact that they must have been consolidated before, and at the time when, the sea came over those countries and deposited shell-fish in the other strata; and from the second fact it follows that they must have been formed when the rocks, in the rents of which they are found, were already formed and dry. Hence these fissure deposits are modern compared to the strata which were formed at the bottom of the sea and of lakes. Nor does any operation now going on upon our globe bear the least resemblance, in Cuvier's judgment, to that by which those deposits must have been made. Upon this, however, great controversy has arisen among his successors.

It was necessary that we should shortly advert to the places where, for the most part, these fossil remains are found; in doing so we have anticipated a few of the conclusions deduced from the consideration of the whole subject. We are now to see what results were afforded by Cuvier's careful examination of the remains, which he instituted after he had with equal care ascertained the exact Osteology of the living animals in each case where the fossil remains appeared to offer a resemblance with existing tribes.

The *first* part of Cuvier's researches is occupied with the *pachydermatous** animals whose remains are found in alluvial deposits.

The *second* part consists of two subdivisions—in one of which are given minutely the whole details of the Paris Basin—in the other subdivision the examination of the animal remains, beginning with the pachydermatous, and then the others that accompany them, whether quadrupeds, reptiles, fishes, or birds. So that the Paris Basin is made the ground of this arrangement, and its Fossil Zoology is gone through without much regard to the general arrangement of the rest of the work.

The *third* part is occupied with the *ruminant* animals, unless in so far as one of its subdivisions, treating of the gaps or fissures of the Mediterranean, also treats of the few other animals which are there found beside the ruminant.

The *fourth* part is occupied with *carnivorous* animals —the *fifth* with *rodents*—the *sixth* with *toothless* or *edentate* animals—the *seventh* with *marine mammalia* —the *eighth* and last, and perhaps the most interesting of the whole, with *reptiles;* including the anomalous species newly discovered, which partake of the nature at once of the reptile and fish or of the reptile and bird.

As no arrangement is yet made of these fossil animals under any of the heads which we have stated, we are

* Animals with thick skins, as the elephant, horse, hog.

at liberty to adopt any order that may appear most convenient; and we shall accordingly begin with those which at first appeared to resemble the known species of the rhinoceros, the hippopotamus, and the elephant, and which a careless observer would unquestionably have confounded with these animals; but they were soon ascertained to be different.

I. Of the fossil rhinoceros four distinct species have been found;* and they are all distinguishable from the four known kinds of rhinoceros—those of India, Java, Sumatra, and the Cape. The fossil animal had a head both larger and narrower than the living kinds, and much larger in proportion to his body. He was also much lower, and a more creeping animal. He, for the most part, had either no incisive teeth or very small ones, but one species had these of a good size. One of the fossil species is distinguished from all the four known ones and from the other three fossil ones, by a still more marked peculiarity; his nostrils are divided from each other not by a gristly or cartilaginous, but by a bony partition, whence the name of *Tichorhinus*† has been given to him, the three others being termed *Leptorhinus*,‡ *Incisivus*, and *Minutus*.

The grinding teeth of the Tichorhinus are also found to have a peculiarity which no other teeth either of any living or any fossil animal have. They are indented at the base in one of the ridges, after being worn down by use. This, as well as the bony partition, affords, therefore, the means of discovering the species. The use of the partition apparently was to support the weight of two large and heavy horns on the nose.

The history of the first of these species, the Tichorhinus, furnishes a remarkable example of the errors into which even able and expert observers may fall when they make more haste than good speed to reach

* Of these there are now nine species, five having been discovered since Cuvier's work.

† From Τειχος, a wall. ‡ From Λεπτος, slender.

a conclusion. A missionary named Campbell having sent home the head of a rhinoceros, being one of several killed close by his residence, and well known to have been so, Sir Everard Home compared it with a fossil head from Siberia, sent by the Emperor of Russia to Sir Joseph Banks; and finding, as he thought, that it was of the same species, he very rashly inferred that the position which affirms the existence of unknown animals among the fossil remains was much weakened by this supposed discovery. Cuvier made a more accurate comparison, and found that the Cape skull was materially different from the fossil one, but resembled the head of the existing species, which Sir Everard Home had also denied. The most remarkable omission, however, of the latter was his never looking to see if there existed a bony partition between the nostrils. This Cuvier did, and found it cartilaginous and not bony. So that the most singular of the new and unknown fossil animals belonging to this class remained still a novelty, even if Sir Everard Home had been correct in all the comparative examinations which he ever did make; and his conclusion of fact from that comparison, even if admitted to be well founded, had no bearing whatever upon the general position against which he had pointed it.

The extraordinary fact of a portion of one of these ancient and lost animals' muscular substance and skin having been found, is further to be mentioned. In a block of ice on the banks of the Wilujii, a river of Siberia, there was discovered this huge mass of flesh, about the year 1770. It was found to have longish hair upon parts on which the existing rhinoceros has only leather; consequently it must have lived in a colder climate than the present animal inhabits. But it appears to have been killed by some sudden catastrophe, and then to have been immediately frozen, else it would have undergone decomposition like the other remains of which the bones alone are left.

There are two species of living elephants, the African and the Asiatic; the former distinguished from the latter chiefly by the length of his tusks, by a peculiar disposition of the enamel in the jaw teeth, and by never having been tamed, at least in modern times. The fossil elephant resembles the Asiatic species most, but differs in some material particulars. It has long tusks, sometimes exceeding nine feet in length; the jaw teeth are differently set; the under jaw of a different shape, as well as other bones; and from the length of the socket bones of the tusks the trunk must have been also very different. These remains* are found in great abundance both in Europe and in America, in neither of which parts of the globe are there now any living elephants of any species produced. In the same strata and caves other animals are also found both of the known and extinct classes; and occasionally shells also. The elephants' bones are chiefly discovered on plains of no considerable elevation and near the banks of rivers. They never could have been transported by the sea over the mountains of Tartary, upwards of 20,000 feet in height, which separate Siberia from the parts of Asia where the elephant now flourishes. It must be added, that, beside those bones, a still more perfect specimen of the softer parts has been preserved by the action of cold than we have of the rhinoceros. In the same country, near the mouth of the river Lena, a mass of ice was found in 1799 by a fisherman, which he could not break or move; but in the course of the next summer it partially melted, when it was found to contain an entire elephant frozen. The neighbouring Tartars with their dogs, and afterwards the bears, destroyed the greater part of the flesh, but the skin and bones were saved. It was found to have hair, and even woolly hair or fur, upon different parts of the body. It must then have been calculated, like the animal of

* There are now known eight species of this fossil elephant.

the Wilujii, for living in a climate much colder than that of India or Africa, and, like that rhinoceros, it must have been frozen immediately after its death. Its tusks were circular, and nine feet (near ten English) long.

Of the hippopotamus, two species* have been found among the fossil bones, both so different from all living animals, that every one bone of each differs from any other known bone; so that even if an error should have been committed in connecting the different bones together, there must be not only two, but more than two, new species thus discovered. These animals abound in the great deposit of fossil bones in Tuscany, in the valley of the Arno, and at Brentford in Middlesex. There are two other fossil species, of which, however, less is known; one of these is very small, not larger than a common hog.

Three pieces of a jaw-bone, with some fragments of teeth, have been found in Siberia; which upon examination prove to have belonged to a singular species, resembling both the rhinoceros and the horse, and forming probably the link between these two animals. The size is larger than the largest fossil rhinoceros. The discoverer, Mr. Fischer, has named it the *Elasmotherium*,† from the thin enamel plate which winds through the body of the tooth in a peculiar manner.

But much more is known of a lost species which approaches the elephant, although differing in some important respects both from the living and the fossil elephant. The most remarkable difference in the Osteology is presented by the jaw teeth, which have the upper surface mamellated or studded with nipples; from whence Cuvier named it the *Mastodon*.‡ When these tubercles are worn down by use, the surface of

* Two more species have since been found. † Ελασμος, thin plate.

‡ Or Mastodonte, which is sometimes, but unnecessarily, rendered by *Mastodonton*: μαστος, mamilla.

the tooth has a uniformly plane or uniformly concave surface. The structure of the vertebræ shows it to have been a weaker animal than the elephant; and the belly was considerably smaller. The lower part of the fore-leg was longer, and the upper joint shorter; the shoulder one-ninth shorter too. The pelvis was more depressed; the tibia and thigh bones materially thicker; and the body a good deal longer in proportion to the height. As it fed upon vegetables, and had a short neck and feet unfit for living in the water, it must have had a trunk; and it also had tusks. It seems to have fed upon the softer parts of vegetables, and to have inhabited marshy ground. Six species* have been discovered of this animal, chiefly differing from each other in the teeth; and of these six two only are well known. The mastodon was long supposed to be peculiar to America, and was sometimes called the Ohio animal; but there have since been found teeth in different parts of Europe, evidently belonging to the two better known species; and the other four kinds are, to all appearance, European.

In the same strata with the remains of elephants, rhinoceroses, and other animals both of extinct genera and species, are almost everywhere found the bones and teeth of horses, very nearly resembling those of the animal now so well and universally known. It yet happens that for want of due attention to a branch of anatomy more familiar to us than any except the human, naturalists have constantly fallen into error in examining fossil bones. Thus Lang, in his history of the figured stones of Switzerland, took a horse's tooth for a hippopotamus's; and Aldrovandinus in one work describes teeth of that class as giants', and in another as horses'; while several authors have confessed that they could not tell to what tribe such remains had belonged. Cuvier did not, therefore, deem himself

* Five more species have since been discovered.

released from the duty of fully examining the common horse's osteology, merely because of the frequent and minute descriptions which had previously been given of it; and his intimate acquaintance thereby obtained with the nature of every bone and tooth, has enabled him to pronounce with confidence upon the existence of horses like our own among the unknown animals which inhabited the earth before the vast revolutions that changed both its surface and its inhabitants. He has, however, justly noted the fact that there is no distinguishing the bones of the horse, the ass, the mule, and the quagga; so that very possibly these remains may have belonged to any of those animals; and very possibly also to none of them, but to some fifth species, now, with the mastodon and other contemporary animals, extinct. The same remark is of course applicable to the bones of the hog and the wild boar, found occasionally among other fossil remains.

The Tapir family in many important particulars resembles the rhinoceros; and those are often found in the same tertiary strata with the rhinoceros, elephant, and mastodon, several species now wholly extinct, but allied to the tapir. Two of these must have been of prodigious size, the largest 18 feet ($19\frac{1}{4}$ English) long and 11 (nearly 12 English) high.* But there are other species, to the number of twelve at least, whose size differs little from that of the tapir; the bones are somewhat different, however, and particularly the teeth, which, from the eminences or ridges upon them, Cuvier made the ground of the genus, to which he gave the name of *Lophiodon*.† It is in different parts of France that all these species were first found: the smaller ones always in strata of fresh water shells, and in company with remains of either unknown land animals, or crocodiles and other river animals now found in hot climates;

* This is now better known, and is called the *Dinotherium*.

† Λοφιον, a small hill, eminence, or ridge.

and in several places the strata in which they occur, have been covered over, after they had been deposited and their bed consolidated, with strata of an origin unquestionably marine. By far the greater part of fossil remains, both those which have been already described, and those which we are afterwards to consider, have been found in sandy, or calcareous, or other earthy strata. But some few are also found in imperfect coal or lignite. In the part of the Appenines where that range meets the Alps there is a tertiary coal stratum, and in it have been found two new genera of pachydermatous animals, and a third in the fresh water deposit near Agen. Cuvier calls these *Anthracotheria.**

The general conclusion which is to be derived from the important branch of the inquiry of which we have been analyzing the resulting propositions, is partly zoological and partly appertains to geology. The former portion of it is, that more than thirty kinds of land animals have left their fossil remains in the strata now forming dry land, but deposited under water; that of these, seventeen or eighteen† are now extinct, and have been wholly unknown since the earth was peopled with its present inhabitants, six or seven being of a genus now unknown, the others being new species of known genera; that twelve or thirteen kinds have, as far as their bones are concerned, the appearance of having belonged to the species which still inhabit the globe, although their identity is far from certain, depending only upon the similarity of their skeletons; and that animals of genera now almost confined to the torrid zone used formerly to inhabit high and middling latitudes. The geological portion of the conclusion is that some of these fossil remains have been buried by the last or one of the last revolutions to which our planet

* Ανθραξ, coal. Of these, seven species are now known.

† According as the Elasmotherium is allowed to be sufficiently distinguished or not.

has been subjected, as they are in loose and superficial strata, whilst other remains in the tertiary strata appear generally to have come from deaths in the course of nature, though some of these too must have perished by a sudden revolution.

II. The Paris Basin presents, in great abundance, the remains of herbivorous pachydermatous animals of two distinct genera, each comprehending several species, and all alike unknown in the living world. The animals to which some of them approach the nearest are the tapirs; but they differ even generically from these, and from every other known tribe. The inquiry into which Cuvier entered for the purpose of ascertaining to which set of bones each particular piece belonged, so that he might be able to restore the entire skeletons by putting together all the parts of each, was long, painful, and difficult in the highest degree. He had first to connect the two bones of the hinder feet together, in each instance, by minutely examining the relation of the pieces to one another; and this process could only be conducted by deriving light from the analogies of other and known animals. He then had the different bones of the fore feet in like manner to put together, in order to restore those fore feet. Next the hinder and fore feet of each animal were to be connected together. Afterwards he had to mount upwards and connect the bones of the body with the several feet. The teeth and head must next be referred to the limbs. Then the vertebræ and then the trunks were to be restored; and then other bones, not yet accounted for, were to have their places found. The result of this most elaborate and perplexing investigation, the details of which occupy the fifth part of a large quarto volume, and are illustrated by between sixty and seventy admirable plates, containing between six hundred and seven hundred figures of bones, fragments of bones, and congeries of bones, may be stated shortly thus:—*There* are of the first genus, which he denominates

*Palæotherium,** six, or perhaps seven, species† principally distinguished by the teeth and the size, as far as the bones are concerned, but which, probably, were much more widely different when alive. One of these resembled a tapir, but was only a foot and a half in length, being about the size of a roebuck. Another was nearly three feet high, and the size of a hog. A third was between four and five feet in height, and about the size of the horse or the Java rhinoceros. It had feet thicker than a horse's, and a larger head; its eyes were very small, its head long, and it had a snout protruding much over its under jaw and lip. In a specimen of one of these species, the first now mentioned, there were actually found some of the animal's softer parts, certain flexible filaments, which, upon being burnt, gave an animal smell, and were manifestly portions of the nerves or blood-vessels. Besides these three species, three, and possibly four others, were distinguished, one the size of a hare.

The other genus was termed by Cuvier *Anoplotherium,*‡ and of these, two species, at least, are distinguishable.§ The first, or *common* anoplotherium, is about the size of an ass, being four or five feet high, and its body four feet long, but with a tail of three feet long; it was probably an animal that lived partly in the water, as it appears made for swimming like an otter. But it has a peculiarity of structure which is to be found in no other animal whatever; its feet are cloven, but have two separate and distinct metacarpal and metatarsal bones, which are soldered together in other animals; it has also its teeth contiguous, while all other animals except man have them apart. The other species, or *secondary* anoplotherium, resembles the former, but is only the size of a common hog. But

* Παλαιος, ancient; θηριον, wild beast.
† Eleven species are now known.
‡ Ανοπλος, unarmed, without tusks.
§ Six species are now ascertained.

beside these anoplotheria properly so called, four other cognate species are found, one of the size and appearance of a gazelle, one the size of a hare, and two of the size of a guinea pig. A curious specimen gives the very form of the anoplotherium's brain, a cast of it remaining in the earthy mass. Its size is extremely small, and Cuvier infers from this that the animal was exceedingly stupid.

All these animals are found in the Paris Basin; but bones of the palæotherium have been discovered elsewhere, namely, at Orleans, Aix in Provence, Montpelier, and Isell. As the specimens from those other places were extremely rare in Cuvier's time, he could not have the same certainty respecting them as from the more copious collections obtained in the Paris district. But he could distinguish at least three different species.

Beside these two new genera, the palæotherium and anoplotherium, the Paris Basin affords two other new genera of pachydermata, the one, called *Chæropotamus*,* resembling animals of the hog kind—the other, *adapis*, very small, being about a third larger than the hedgehog, which it also resembled in structure. There are found, too, the remains of five or six kinds of carnivorous animals, one of them being of enormous size, and resembling a tiger. Another has projecting bones to support a bag or purse as in the kangaroo kind; but it is of a genus of marsupial animals now found only in America, being a sort of opossum. The Basin, besides, affords a considerable number of tortoise remains, some fish bones, and even perfectly complete skeletons of fish, and ten species, at least, of birds, all now unknown, but one of which resembles the Egyptian ibis. It is very remarkable that in one specimen, brought to Cuvier while his work was printing, the windpipe was preserved, and the mark or mould of the brain appeared upon the surface of the gypsum.

* There are now three species known.

III. Of ruminating animals the fossil deposits present many remains. There are of the deer, beside divers that closely resemble known species, no less than twelve* species wholly unknown among the existing inhabitants of our earth. One has enormous horns, six feet from tip to tip, and of this animal we know nothing among existing species, though it comes nearest the elk. Two kinds are somewhat like roebucks, and of that size. The fissures of the Mediterranean give six new species,† of which that found at Nice is like an antelope or sheep.‡

None of our common oxen are found in a fossil state, unless in morasses or peat bogs, where they have certainly been buried while the globe's surface was in its present condition, and peopled as we now find it. But animals of the same genus certainly existed in the age of the elephant and rhinoceros, and of the extinct species.§ There prevails no small uncertainty as to the identity of the fossil bison and musk buffalo with the living species of the former in Europe and of the latter in America; but the remains which have been found of a kind of ox, appear different from any known species, and it appears that no buffalo resembling either that of the East Indies or that of the Cape has been found in any place.

The conclusions, both zoological and geological, from this part of the investigation and from the examination of the remains found in the Paris Basin, in every

* No less than twenty-eight species are now known.

† In the Résumé to Parts III. and IV., Cuvier says, "Of the six deer found in alluvial deposits, one with large horns is entirely unknown; of the four in fissures, three are unknown, at least in any but most distant countries. Another, that of Orleans, is quite unknown, as are the two species of lagomys found in the fissures."

‡ A thirteenth new species was at one time supposed to have been found in the Swedish province of Scania; but Cuvier, before the last volume of his work was printed, had reason to believe that this animal belonged to one of the tribes formerly known, and still living in the north of Europe.

§ Of these there are now seven ascertained.

respect tally with those to which we were led by a consideration of the pachydermatous remains under the first head of the inquiry.

IV. There are found in caverns both in France, Germany, Yorkshire, and Devonshire, and in the fresh water formation of Val d'Arno, in Tuscany, the remains of many animals, some extinct and others no longer inhabitants of the same temperate latitudes, but confined to the frozen and the torrid zones. By far the greater part of these animals belong to the carnivorous class, except in the Yorkshire caves, where many of the herbivorous kind are also to be found. In the foreign caves the bear is the most numerous, and presents extinct species. In the Yorkshire caves (at Kirkdale) the hyæna predominates. In the German caves hyænas are comparatively few, and in Val d'Arno not more numerous. In Kirkdale there are very few bears. The race of lions and tigers is much more rare than any of the others. Not above fifteen have been found in Germany, while there have been found hundreds of bears; and in Yorkshire, where hyænas abound, very few lions and tigers are traceable. Of the wolf and fox, some are found, but not so many in Yorkshire. There is also a very large kind of dog traced, which must have been five feet in height and eight in length from the mouth to the tail.

Of bears it appears, after a very close examination, that there are found, at least two species* larger than those now known, and a third which, both in size and other particulars, so nearly approaches the common bear, that Cuvier does not regard it as a new species. But it seems as if the one found in Tuscany formed a third kind of animal now extinct.

The hyæna† is found not only in the caverns and other quarries where the bear abounds, but also in the alluvial strata with the elephants and rhinoceroses. In

* Seven more have since been added. † Now eight species.

Kirkdale cave his dung has been distinctly recognized by a comparison with that of living hyænas; and the particular crack which he makes in the bones of the beasts devoured by him to get at the marrow, has, in like manner, been identified by actual comparison. Nevertheless the fossil animal differs from the living one in some material respects, particularly in size, and in having his extremities both thicker and shorter. The caverns contain two species* of a huge animal of the felis (or cat) kind, considerably larger than the lion or the tiger, beside some few resembling living species in size. One is between one-eighth and one-ninth larger than the lion, and has its trunk more convex in the lower outline. A new, but smaller, species of the felis kind is also found in the Mediterranean fissures.

In the dog tribe there has been found a wolf or dog,† but more probably the former, which differs, though slightly, from any known species, in having the muzzle shorter in proportion to the skull; and also a species has been observed clearly new of the same genus. We as yet only know of it by two of his jaw teeth, found at Avaray, near Beaugency. He must have been eight feet long and five high. The Paris Basin affords, likewise, another new species of the dog kind, but not materially varying in point of stature. The common fox, however, is found, and also the dog and wolf, in the caves.

The caves afford a considerable number of bones of the weasel and glutton,‡ closely resembling the existing species. The latter animal is only known now in the higher latitudes; but in the caves we find his remains mixed with those of animals belonging to the temperate and the torrid zones.

It is thus shown by the inquiries which comprise the third and fourth part of this great work, that the

* Now fifteen.

† Ten species are now known.

‡ Of the fossil gulo two species are now ascertained.

former inhabitants of these regions were wholly different from the present population. Even the animals of hot climates here found, and referable to existing genera, must have differed entirely from those species which survive in the torrid zone, because they could exist in a temperature now wholly foreign to their nature. The rein-deer and the lion, the sloth and the elephant, all found in the same places, show that the climate of those latitudes remains nearly the same, but that their inhabitants have been changed.

In all these researches one blank is immediately perceptible. There are not only no human remains whatever, but there are none of apes or of any of the genus of quadrumanes. Animals far less in size, and whose bones would much more easily have perished, as rats and mice, have left their skeletons with those of the largest beasts; but of the monkey tribe no vestige whatever is to be discovered; and the conclusion is inevitable, that the strata were deposited, the fissures filled, the caverns strewed with bones, at an age anterior to the existence of that tribe, as well as to the creation of our own species. Thus it was when Cuvier wrote.*

V. Beside the animals of the *Rodent* description, found in the Paris Basin and the Mediterranean fissures, rabbits, lagomys, field mice, there are several others in the alluvial strata and caverns,—some apparently of known, and others, certainly, of unknown kinds. The hare has been traced at Kirkdale; the beaver near the Rhine; two new species† of the beaver near Rostoff, in the south of Russia; another species, also unknown, at Œningen.

VI. The toothless or *Edentate* animals afford some

* This refers of course to the state of discovery in Cuvier's time. There are remains of the monkey said to have been lately discovered in the South of France and in the Himalaya Mountains; it is said also at Calcutta. *But* the proofs are not clear.

† Now four are known, and three of lagomys.

varieties still greater than those to which our attention has as yet been directed. None of the known species of this tribe are to be found in any of the strata, fissures, or caves in Europe. But three genera entirely new, with two of which at least there are ample materials for becoming acquainted, have been found in America, and these are deserving of our best attention.

The first is the animal named by Jefferson, from the size of his feet, or rather what he supposed claws, the *Megalonyx*,* and respecting which he fell into an error as we formerly stated. Cuvier preceded his examination of this as of all other animal remains by a thorough investigation of the osteology of living animals of this family; and it is the result of his careful inquiry that the bones found in America and described by Jefferson, and of which both casts and drawings were sent over, as well as a tooth, belonged to an animal of the sloth tribe, but wholly new, and now quite extinct. The tooth was cylindrical, and worn down on the top, but cased round with enamel like a sloth's, and not at all like a cat's. In the paw, the second phalangal bone was symmetrical. This bone is curved and not symmetrical in animals that raise up and draw back the claw, as all the cat kind do. The first phalangal bone, too, was the shortest; whereas the lion and others of the cat kind have that bone the longest. But from the known species of sloth it differs most strikingly in its stature, which was equal to that of the largest oxen, those of Hungary and Switzerland, and a sixth larger than the common kind.

The second of these new animals has been termed *Megatherium*, from his great size, and the remains are found in South America. From his teeth it appears that he lived on vegetables, but the structure of his very long fore paws and nails shows that it was chiefly on the roots. He possessed also good means of defence,

‡ Two species are now known.

and so was not swift on foot. His covering seems to have been a thick and bony coat of mail like the armadillo's. His length was twelve feet and a-half (near thirteen feet and a-half English), and his height seven feet (about seven feet and a-half). From the sloth he differs not only in size but in other particulars; for example, his fore legs are much nearer the length of his hinder legs than in the sloth, which has the former double the latter. But, on the other hand, the thickness of the thigh bone in the megatherium is much greater than in any of the known sloth tribe, or indeed any other animal either known or extinct; for the thigh bone is about half as thick as it is long.

The third of these new animals was known to Cuvier only by one fragment which he examined. It was a toe; and from a careful discussion of its form and size he inferred that the animal belonged to the edentate tribe of Pangolins, and that, if so, its length must have been twenty-four feet (twenty-six English), and its height in the same enormous proportion. The bones were found in the Palatinate near Eppelsheim.*

VII. The course of our analysis has now brought us to the family of the *Sea Mammalia,* and these supply new food for wonder. So different from the bones of any living animals are those remains which have been examined, that a new genus is formed consisting of several species, and bearing the same relation to the cetacea, or animals of the whale tribe, that the mastodon, palæotherium, and anoplotherium do to the pachydermata, or that the megalonyx and megatherium do to the edentata. He terms the genus *Ziphius,* from its having a sword-like head. One of these was found near the mouths of the Rhone. The dimensions are not given by Cuvier, but from the drawing, the head appears to have been about three feet in length. The remains of a second species of ziphius were found thirty

* Subsequent discoveries have made it probable that this toe belonged to the Dinotherium.

feet under ground at Antwerp, and between nine and ten under the level of the sea at low water. The head is considerably larger than that of the first mentioned species. The head of a third species is found in the museum at Paris, but with no account of its history.

Besides this new genus there are other cetacea of new species discovered among the fossil bones. At Angers a Lamantin of an extinct species has been traced. The remains of a dolphin, which must have been twelve or thirteen feet long, and different from all the known species, have been found in Lombardy. In the Landes another dolphin, which must have been nine or ten feet in length, has been discovered. A third kind of dolphin, different from any now living, has been found in the department of L'Orne, while a fourth, also found in the Landes, nearly if not wholly resembles the ordinary dolphin. In Provence a cetaceous animal of an unknown species is found, somewhat like the hyperodons.

In the neighbourhood of the Ochil hills in Scotland the fragments of a whale's bones have been found in a recent alluvial stratum, at only eighteen inches' depth, with a part of a deer's horn near. It must have been a whale of some size, as the vertebræ were eighteen inches broad, and one of the ribs ten feet long. But it is most probably one of a kind still existing in our seas, from the place where it was found.

In the mountains near Piacenza there have been found the bones of a small whale. Its length was twenty-one feet (near twenty-three of ours) and its head was six feet (near six feet and a-half) long. The place where these bones lay was a clay stratum with numberless shells all round, and oysters clinging to the bones. This animal was in a tertiary formation, six hundred feet above the plain of Italy. It appears to be of a new species.

In the very heart of the city of Paris have been found the bones of another whale, far larger, and of a species wholly unknown. Its head must have been fifteen or sixteen feet long, and its body fifty-four or fifty-five. It was found in a compact sandy bed in digging under the cellar of a wine-merchant.

The conclusion to which these Researches unavoidably lead is that the earth in its former state did not differ more widely in the races which inhabited it than the sea did—that ocean which was itself the great agent in producing many of the changes that have at various times swept away one race of living creatures from the surface of the globe, and mixed up their remains with those of animals engendered in its own bosom.

VIII. We have now reached the last and the most singular portion of these Researches; the examination of *Reptiles* whose relics are found in many of the stratified rocks of high antiquity.

In the calcareous schist, near Monheim, whence the stones used in lithography are gotten, a new species in the crocodile family is found, whose length must have been about three feet. At Boll, in Wirtemberg, another, apparently of the same kind, has been discovered. At Caen oolite quarries, a different and equally unknown species is traced; its body is between four and five feet long, and its whole length thirteen. Others of this family have been found in the Jura, and there they are accompanied by the fresh water tortoise. At Honfleur another species is found, and the remains of two other unknown kinds have been discovered near Harfleur and Havre.

Beside the remains of crocodile animals found in these more ancient strata, there are many also found in the more recent beds, where the bones of the palæotheria and lophiodons are deposited. The Paris Basin, the marl pits of Argenton, Brentford, and other places have furnished these specimens. But whether they were of different species from those new ones found at

Monheim, Caen, and Honfleur, the examination which they had undergone in Cuvier's time was too imperfect to determine. They have since been shown to be different.

It deserves to be remarked of the new species of crocodiles, that their difference from the known kinds exceeds in manifest distinctness that of almost any other animals which are of the same genus, and do not differ in size; for the vertebræ, instead of being, as they are in the crocodiles now alive, concave in the front and convex behind, are convex in front and concave behind. This at once furnishes a very triumphant answer to those doubts which have been raised as to the novelty of the species, and still more signally discomfits the speculations of those who fancy that the difference perceived in fossil bones has been caused by change of temperature or of diet, or by the passing from the living to the petrified state.

The examination of fresh water tortoises, of the genus trionix, whose remains are found in the plaster quarries and other strata, offers similar results. Thus at Aix in Provence a trionix of a new species is found. Another species, also new, is found in the Gironde; and two others have been traced less distinctly in the gravel beds of Hautevigne (Lot et Garonne) and of Castelnaudary.*

Fossil fresh water tortoises, of the genus emys, give the same results. They are found in the molasse of Switzerland, in the Sheppy clay near London, and in the limestone ridges of the Jura.

Fossil sea tortoises offer the like appearances. One of an unknown species is found near Maestricht, the genus being still living in the sea, and familiar to our observation. So that altogether the examination of tortoise remains leads to the same inferences of islands having existed in the ocean at a former period, inhabited chiefly by reptiles or oviparous quadrupeds, and before

* Eight species have now been traced.

the creation of any considerable number of the viviparous orders.

As we proceed towards the close of these Researches the subject rises rather than falls off in curiosity and interest. We now come to the family of lizards, by which is here understood all the old genus of Lacerta (Lin.), excepting the crocodile and salamander tribes.

In the celebrated fossil fish deposits of Thuringia are found the remains of a monitor, of a species somewhat varying from the known species in two particulars, a greater elevation of the vertebral apophyses, and a longer leg in proportion to the thigh and foot. Remains of a similar aspect occur in France near Autun, and in Connecticut in North America.

In the strata of fine and granular chalk near Maestricht, between 400 and 500 feet in thickness, are found the remains of a huge reptile, which Mr. Faujas represented as a crocodile, following the opinions of the people in that neighbourhood; but so celebrated an anatomist as Adrian Camper was not to be thus deceived, and he proved it to be an animal of a new genus, related to the monitor, and also to the iguana; it seems to be placed between the fishes on the one hand and the monitors and iguanas on the other. But the size constitutes its most remarkable difference when compared with these. They have heads five or six inches long; his was four or five feet, and his body fifty. He was therefore a lizard exceeding the size of a crocodile; just as the extinct tapir was the size of an elephant, and the megalonyx was a sloth the size of a rhinoceros. It appears that, like the crocodile, he was aquatic and could swim; and that his tail was used as a scull, moving laterally in the water, and not up and down like the cetacea, an order to which the elder Camper at first rashly referred him.

In the canton of Meulenthal, at Monheim, ten feet below the surface, and near some kinds of crocodile remains, bones were discovered of another unknown sub-genus of the order Saurus, and which Cuvier calls Geosaurus, and places between the crocodile and the monitor. It was apparently twelve or thirteen feet long, that of Maestricht being fifty.

A large animal of this family is found to have been an inhabitant of the same ancient world. At Stonesfield, in the neighbourhood of Oxford, Dr. Buckland discovered his remains in a bed of oolitic calcareous schistus under a solid rock of forty feet thick. The thigh bone is two feet eight inches in length, which would seem to indicate a body in the whole forty-five feet long. But even if his tail were not in the proportion of the lizard's, as this calculation assumes, his length must be, according to the crocodile's proportions, thirty feet. This animal approaches the geosaurus of Monheim, and also, in other respects, has some affinity with the crocodile and monitor; but in size he greatly exceeds the crocodile, and comes nearer the whale. His voracity must, from his teeth and jaws, have been extreme. He was also an amphibious animal; for his remains are surrounded with marine productions. The genus has been called *Megalo-saurus*. Teeth and bones of the same genus have been since discovered in Tilgate Forest, Sussex. Mr. Mantel has found in the same place the thigh bone of a much larger animal. Other reptiles have been found in the Muschelkalk quarries near Luneville.

But there are animals of the family of saurus yet more strange, if not for their size, at least for their anomalous structure and habits. A reptile is found of a genus so extraordinary as to comprehend within itself the distinguishing nature both of the lizard and the bird. It has a very long neck, and the beak of a bird. It has not, however, like a bird, wings without fingers to strengthen them; nor has it wings in which the thumb alone is free like a bat; but the wings spread by a single long finger, while the other fingers are short, and with nails like the fingers of ordinary anterous (or unwinged) animals. From these circumstances Cuvier has named the genus* the *Pterodactylus.*† It was first discovered by the late Mr. Collini, a Florentine, settled at Manheim, and formerly attached to the family of Voltaire, of whom he published some memoirs. The skeleton, nearly perfect, was found in the marly stone beds of Aichstadt in the county of Pappenheim; but Mr. Collini fell into very great mistakes respecting the genus of the animal, which he supposed to be of marine origin, from not accurately investigating its osteology. The celebrated Sœmmering contended that it was one of the mammalia, resembling a bat, and other naturalists held the same opinion. But Cuvier has most satisfactorily shown, chiefly from its jaws and vertebræ, its shoulder-blade and sternum, that it is between a bird and a reptile, a flying reptile. The tail is extremely short, and this indicates the animal to have used its wings chiefly for locomotion: indeed, from its very long neck, it must have had great difficulty in either walking or crawling. When at rest, it must have stood like a bird on its hind legs, and also, like some birds, have bent back its long neck in order to support its very large and heavy head. Another species of the same genus, having a much shorter beak (for that of the former is longer than the whole body), has also been found near the same spot. It is much smaller. Very scanty remains of a third species also occur, found in the same quarries. Its size must have been nearly four times greater than that of the kind first mentioned, and it must have presented one of the most monstrous appearances which can be conceived, according to our present experience of animal nature.

The two last discoveries among the animals of a former world, which these researches have disclosed, remain to be mentioned; and they are, in the eyes of the naturalist, the most wonderful of the whole, although

* There are now ten species observed.

† Πτερον, wing; δακτυλος, finger.

to an unlettered observer they may appear less strange than the tribe we have just been surveying. One of them has the muzzle of a dolphin, the teeth of a crocodile, the head and breast of a lizard, the fins or paddles of a whale, but four instead of two, and the back or vertebræ of a fish. This has been named the *Ichthyosaurus*. The other, being apparently nearer to the lizard, has been called the *Plesiosaurus;** and has also four paddles like those of a whale; the head of a lizard, and a long neck like that of a serpent. Both are found in the older secondary strata of the globe; in the limestone marl or greyish lias, filled with pyrites and ammonites, and in the oolite beds of the formation called Jurassic. They are both chiefly found in England, and were first discovered there.

Sir E. Home, in 1814, made the first step in the discovery of the Ichthyosaurus; having obtained some bones found on the Dorsetshire coast, thirty or forty feet above the level of the sea. He gradually obtained more of these remains, until 1819-20, when the discovery was completed. But he seems to have been unfixed and variable in his opinion respecting the animal; and after believing for some time that it was partly a fish, he ended by believing it to be no such thing, and changed its name from ichthyosaurus, which Mr. König had given it, as early as 1814, to *Proteosaurus*, supposing it to have some affinity with the proteus as well as the lizard.

The ichthyosaurus is most abundant in the lias strata in the lower region of the Jura formation. Its remains are not confined to Dorsetshire; they are found in Oxfordshire, Somersetshire, Warwickshire, and Yorkshire. But at Lyme they abound as much as those of the palæotherium do in the pits of Montmartre at Paris. Some few specimens are found near Honfleur and at Altorf; in Wirtemberg, also, a nearly complete skeleton

* Πλησιος, near.

has been discovered. Four* distinct species were ascertained by Cuvier, chiefly differing from one another by their teeth, that is to say, as far as their osteology goes.† In the general features of their bones they all approximate to one another. The head resembles that of the lizard, although with material differences, and even having some other bones. The eyes are extremely large, differing in this from all the greater animals both sea and land. The cavity in some specimens is above a foot in diameter. Each eye is protected by a shield of bone, composed of several pieces knitted together. The vertebræ are very numerous. In some specimens as many as ninety-five are to be seen; and these differ entirely from the vertebral system of the lizard, resembling rather that of fishes, for they are flat like backgammon, and concave on both sides. The animal has four fins, or paddles, each composed of six rows of small bones, nearly one hundred in all, and so fitting into one another, that he could paddle about by means of them, moving with more elasticity than if the bones had formed a single piece. The teeth are sharp. This creature could only breathe the air, and so must often have come up to the surface. Yet, again, he could only move in the water, and was still less able to crawl on land than even the sea-calf. The length, in some cases, reaches to twenty-four or twenty-five feet. In the strata where these bones are found there are many of the cornu ammonis and other marine shells, and remains of crocodiles exist in the same strata.

The plesiosaurus was first observed in 1821, by

* Four species have since been added to these.

† It cannot be too steadily kept in mind that when a specific difference has once been ascertained, so as to distinguish one of these extinct races from another, the amount of that difference is no measure at all of the diversity which may have existed between the two animals. Tribes the most unlike have general resemblances in the bones, the sub-stratum on which the muscular parts are placed. Witness the ease with which unlearned persons, nay, even naturalists carelessly observing, have taken the skeletons of lizards for those of men.

Mr. Conybeare and Mr. Delabeche; and in Cuvier's time its remains had only been found in England, unless those discovered at Honfleur belong to this genus. The discovery was fully made in 1824. The distinguishing feature, the long neck, has many more vertebræ than even a swan's. In the fine specimen from Lyme there are in all eighty-seven vertebræ, of which thirty-five belong to the neck and twenty-five to the tail. The vertebræ, though their axis is very short, resemble the crocodile's more than the lizard's. The teeth are pointed and slender. The paddles consist of many bones, in rows like those of the ichthyosaurus; but they taper more, consist of fewer pieces, not above fifty, and are longer than those of the ichthyosaurus, nor do they form a kind of pavement like his. Five species* of this animal were distinguished by Cuvier. That found at Lyme appears to have been seven or eight feet long; but other species, from one jaw bone which has been discovered, must have reached the length of twenty-eight feet.

The eighth and last part of these Researches which we have just surveyed, is remarkable, as regards the skill and diligence of the illustrious author, for two particulars. *First*, The extraordinary success of his indefatigable investigation from very scanty materials deserves especial attention. In some cases he had only one or two bones to examine and to reason from. In others he had a far greater number; sometimes he had the whole skeleton in scattered parts; in a few instances the whole together in their natural juxtaposition and connexion. But he found where he had many bones, that from a single one, or from two, he could have reached the very same conclusions which the examination of the whole led him to. This was observable in a very remarkable manner when he investigated the mosasaurus, or saurus found at Maestricht.

* Three have since been added.

He had not examined more than the jaw bone and the teeth when he knew the whole animal; but he says that a single tooth discovered it to him: he had got the key; after that every other part fell in at once of itself into its proper place. *Secondly*, Although he was not the discoverer of either the ichthyosaurus or plesiosaurus, and had to tread on ground which his eminent and able predecessors had gone over, his researches even here were quite original. He collected all the evidence, whether by drawings, descriptions, or models, of what had been before them; but he also enlarged his collection of facts by numberless specimens both of the same kind which they had examined and of different kinds never submitted to their view. He investigated the whole as if the field had been still untrodden and the soil yet virgin; and accordingly his work, even in this subordinate branch, is far from being a repetition; his inquiries far from being a mere reiteration of theirs. Where he does not vary or extend the results at which they had arrived, he carefully confirms their propositions, and ascertains the truth of their learned conjectures; so that he adds to the precious monuments of his predecessors, by either enlarging the superstructure or strengthening the foundation.

That such a guide to our inquiries is worthy of all confidence, no one can doubt. That even his authority, the weight of his opinion, is very great would be a proposition as indisputably true, if in matters of science it were lawful for the learned to pay any deference to mere authority; yet even here ignorant men may bow to him, and receive his doctrine with a respect which they might be justified in withholding from others. But his system makes no such appeal, and requires not to be received upon terms like these. He has given us without any reserve every particular which his whole researches presented to his own view, and preferring the risk of being tediously minute to the chance of leaving any point unexplained, or any position without its needful proof, there is not a fragment of bone which he has ever examined, and on which he raises any portion of his philosophy, that he has not both described with the fulness of anatomical demonstration, and offered to the eye of his reader in the transcript of accurate and luminous engraving. His work is accompanied with between forty and fifty maps and sections of strata, above 250 plates representing upwards of 3,800 skeletons, bones, teeth, and fragments. These are all presented to the examination of the expert, in their connexion with the author's description both of what the diagrams can, and of what they cannot, fully represent. But they are also presented to the uninformed, who can, by attentively considering them, institute a comparison between the structure of known and living animals, and those of which the earth's strata contain only the remains. Giving Cuvier only credit for having correctly written down what he observed, and accurately represented in his figures the subjects of his examination, we are enabled to see the whole ground of his reasoning: we can mark the points in which a fossil animal resembles a living one, and those in which the two differ; and we have even a higher degree of evidence in behalf of the author's conclusions than we have in reading Sir Isaac Newton's experiments upon light, because everything in this case depends upon configuration, which a drawing can accurately represent, whereas much in the optical case must needs turn upon appearances observed by the experimenter, and which no drawing can convey to our apprehension.

If again we compare the certainty and fulness of the proof in this case with that which we have in examining any anatomical proposition, or any doctrine of natural history, whether of animals or of plants, we shall still find it of a separate and higher kind. For in those branches of science much more is necessarily left to description. The question here is always one purely osteological as regards the animals; and osteology is of all branches of anatomy, whether human or comparative, the one where most depends upon mere figure, and where of consequence the reader can approach most nearly to the observer in weighing the proofs on which his demonstration rests. The geological matter bears but a small proportion to the zoological in these inquiries. It is indeed of the highest importance; but it is incapable of much doubt, and admits of no mistake or imposition—for the strata where the different animal remains have been found are well known, and, in the very great majority of cases, are of easy access to all. The sciences of geology and mineralogy are sufficiently certain, at least for the main purposes of the inquiry; the names and description of the beds of the globe's surface are the portions of those sciences upon which no doubt or difficulty can exist; and the great body of Cuvier's results remains unaffected by any differences of opinion upon speculative geology.

Thus the comparison stands as to the degree in which the evidence is made plain to the reader of Cuvier's researches, and the reader of other records of discovery in the inductive sciences. But let us extend our view a little farther, and compare the proofs before us in these volumes with those reasonings upon which the assent of mankind has been given, and is continued unhesitatingly, to the great truths of the mixed mathematical sciences. The reader of the 'Principia,' if he be a tolerably good mathematician, can follow the whole chain of demonstration by which the universality of gravitation is deduced from the fact that it is a power acting inversely as the square of the distance to the centre of attraction. Satisfying himself of the laws which regulate the motion of bodies in trajectories around given centres, he can convince himself of the sublime truths unfolded in that immortal work, and must yield his assent to this position, that the moon is deflected from the tangent of her orbit round the earth by the same force by which the satellites of Jupiter are deflected from the tangent of theirs, the very same force which makes a stone unsupported fall to the ground. The reader of the 'Mécanique Céleste,' if he be a still more learned mathematician, and versed in the modern improvements of the calculus which Newton discovered, can follow the chain of demonstration by which the wonderful provision made for the stability of the universe is deduced from the fact that the direction of all the planetary motions is the same, the eccentricity of their orbits small, and the angle formed by the plane of their ecliptic acute. Satisfying himself of the laws which regulate the mutual actions of those bodies, he can convince himself of a truth yet more sublime than Newton's discovery though flowing from it, and must yield his assent to the marvellous position that all the irregularities occasioned in the system of the universe, by the mutual attraction of its members, are periodical, and subject to an eternal law which prevents them from ever exceeding a stated amount, and secures through all time the balanced structure of a universe composed of bodies, whose mighty bulk and prodigious swiftness of motion mock the utmost efforts of the human imagination. All these truths are to the skilful mathematician as thoroughly known, and their evidence is as clear as the simplest proposition in arithmetic is to common understandings. But how few are there who thus know and comprehend them! Of all the millions that thoroughly believe those truths, certainly not a thousand individuals are capable of following even any considerable portion of the demonstrations upon which they rest, and probably not a hundred now living have ever gone through the whole steps of those demonstrations. How different is the case of the propositions discussed by Cuvier and his predecessors! How much more accessible are the proofs on which their doctrines repose! How vastly more easy is a thorough acquaintance with the 'Recherches' than with the 'Principia' and the 'Mécanique Céleste!' How much more numerous are they who have as good reason for fully believing the propositions, because as great facility of thoroughly examining the proofs, as first rate mathematicians can have for assenting to Newton's third book, and La Place's great theorem, or as common readers have for admitting any of the most simple truths in the easiest of the sciences!

The extraordinary truths unfolded by the 'Recherches' we have had an opportunity of stating in detail. But it is necessary to revert to some of the more general conclusions in their more immediate connexion with the great subject of these volumes. The Illustration derived to theological inquiry from the powers of inductive investigation in this branch of science, and the Analogy found between the two kinds of demonstration, was stated in the Introductory Discourse; but these form by no means the whole contribution which this new branch of knowledge furnishes to Natural Religion. Before the nature and extent of that aid could be understood, it was necessary that the details of the science itself should be considered, and its general principles unfolded, together with the grounds upon which they rest. We are now more particularly to make the application.

To the geologist, as Cuvier has well observed, the vast periods of time over which the phenomena that form the subject matter of his inquiries have extended, offer the same kind of obstruction as the astronomer finds from the immense space over which his researches stretch. The distance of time is to the one as great a difficulty as that of space is to the other in prosecuting his researches. Yet as the properties of light, and its relation to media artificial or natural, furnish a help to the senses of the astronomer, so the endurable nature of the principal portions that compose the framework of animal bodies give invaluable assistance to the labours of the geologist and anatomist, supplying records which it is as physically impossible he should have in any history of past changes on the globe, as it is that the naked eye of the astronomical observer should penetrate into boundless space. The most minute bones of small animals, even their cartilaginous parts, and the most delicate shells of sea or river fishes, are found in perfect preservation. These shells are found, too, on ground now and for ages lying high above the level of any waters, in the middle of the hardest rocks, reaching the summits of lofty mountains, lying in vast layers of a regular form and solid consistency, and which seem to demonstrate the proposition that the sea in former ages was spread over the regions where those strata were formed, and lay there long and quietly. The level parts of the earth, which to an observer who only regards its surface seems always to have been in its present state, can hardly be penetrated in any place without showing that it has undergone such revolutions and been under the sea for ages; while the bottom of the ocean has at those remote periods been dry land. But when we ascend to greater heights, we find the same proofs of former changes; marine remains often show themselves on Alpine summits, but their kinds vary much from those of the lower regions; they are exposed to view by the layers in which they lie imbedded being no longer horizontal and buried deep under ground, but nearly vertical, broken in pieces, and thrown variously about. These strata have for the most part been of a formation long prior to that of the horizontal ones, and were at one time displaced, and elevated and rolled about; the ocean was the great agent in their formation as in that of the strata which it afterwards deposited horizontally around them; the ocean, too, was the agent which, after having first deposited, afterwards dislocated and raised them into rocks, promontories, and islands, amidst which the strata still found horizontal were laid.

This ocean, at different times, not only held in solution different dead matter, but was inhabited by animals of kinds that exist no more. When it last left the earth and retreated into its present position, the only one in which we have ever known it by actual observation, its inhabitants nearly resembled those which still live and swarm in its waters. But at more remote periods, and when forming its more ancient deposits, it was the receptacle of animals of which not a living trace now remains; animals all whose species are extinct; animals of genera absolutely different from any now known, and which sometimes united together in one individual frame, parts now only found separate in distant and unconnected tribes.

Again, the intermixture of land animals and of fish the inhabitants of fresh water only, with those of marine origin, shows that several successive irruptions of the ocean must have taken place, and that after it remained covering the land during successive periods, it retreated successively, and left that portion of the globe dry. Nor can there be any doubt that large portions of the earth now uncovered and inhabited by the human species and other tribes of living animals had, before it was last covered by the sea, been dry, and been inhabited by a race of animals of which their fossil remains are all that we can now trace.

It is probable, too, that many of these mighty revolutions have been sudden, and not effected by gradual encroachments upon the earth, to destroy its inhabitants. The examination of masses of flesh belonging to some of the race destroyed by the last change, and preserved by the frozen water in which they were imbedded, seems to prove that the death of the animals, and their envelopment in water, the coagulation of the water, and the introduction of a frozen climate, were simultaneous; for the putrefactive process had not commenced till thousands of years after the destruction of life, when, the ice being thawed, the exposure to heat and air began the decomposition. But the sudden violence by which these last changes were effected is equally conspicuous in the transport of huge blocks from one part of the country to another in which they were manifestly strangers.

But we ascend to greater heights on the surface of the globe, and we find the scene changed. We are now upon the vast and lofty chains of solid rock which traverse the central parts of the different continents, separate the rivers that water and drain them, veil their summits in the clouds, and are capped with never-melting snows. These are the primitive mountains; formed before any of the other new-made strata whereof we have already spoken, because they penetrate them vertically; and even these primeval rocks show by their crystallization, and occasionally by their stratified forms, that they, too, were once in a liquid state, and deposited by waters which anciently held them in solution and covered the places they now fill. In these, as we ascend to the most ancient, no animal remains at all are found. The shells and other marine productions so abundant below, and in the more recent layers of the globe, here cease altogether to exist. The primeval rocks, therefore, were first held in a liquid state, and afterwards deposited, by an ocean which contained in its bosom no living thing; an ocean which before covered, or washed, a continent, or islands, on which life never had existed.

There is also little doubt, according to Cuvier, though we give not this as an incontestible proposition, that the prodigious changes which we have been contemplating must have been operated by a force wholly different from any that we now perceive in action upon any portion of the globe. The power employed to work some of the displacements of which we see the traces is shown remarkably in the insulated masses, found removed from great distances, and lying still at vast heights. On the Jura, at near 4,000 feet above the level of the sea, are found blocks of granite evidently carried from the Alps, one of which, containing 50,000 cubic feet of stone, has been removed and placed in its present position after the formation of the strata on or among which it lies,—strata, the materials of which do not fill its interstices, but have been rent and broken by its fall. None of the operations now observed on the earth's surface satisfactorily explain either this or the other revolutions in question. The effects of weather, either in the fall of rain, or in alternate freezing or thawing of water, though sufficiently powerful and very beneficial upon a small scale in decomposing stones and pulverizing earths, are confined within comparatively narrow limits. The action of rivers in wearing down their banks, and changing the position of their beds, is restricted to those banks and beds, and is of slow and almost imperceptible operation, unless in some cases of rare occurrence, where a mountainous eminence being gradually undermined may fall and dam up a river and cause a lake to be formed, or where a lake may be let out of its reservoir by the wearing away of some ridge forming its dam or head, and so inundate the country below—events barely possible be it observed, and of which the period of authentic history records scarcely any instance. Then the encroachments of the sea are even more gradual than those of rivers; nor can any proof be found, in all the time over which authentic human annals reach, of a material change in position of the ocean with respect to its shores; the utmost it has ever done being to wear away an isthmus here and there,* or cover a mile or two of low and flat coast.† The wonderful force of a column of compressed water, in a vertical fissure connected with a subterraneous sheet of it, however shallow, but filling a broad space—

* There seems reason, from some ancient authorities, to believe that the Isle of Wight was once a peninsula when the tide was out, to which tin, the staple of the ancient British exportation, was carried in waggons at low water to be shipped for Gaul.

† The estate of Earl Godwin in Kent, now covered by the sea, is one of the principal examples of this kind of change; and there must clearly be great exaggeration in the accounts given of it.

the resistless power of such a column to move about any superincumbent weight—has, perhaps, been too little taken into account as an agent in effecting changes on the earth's surface. But these operations must be all merely local. Volcanic action is still more topical in its sphere; and though violent enough within these narrow limits, produces consequences wholly confined to them, and unlike those which are under consideration. Lastly, whatever effect could be produced by the motion of the earth is of incomparably a more slow and gradual kind than any now enumerated. The motion of the poles round the plane of the ecliptic, and the nutation of the axis, are movements of this kind, and never exceeded certain narrow limits. The rotation of the earth has a regular and defined tendency to accumulate matter towards the equator, and flatten our globe at the two poles, but no other; and certainly neither a sudden nor a violent effect can be operated by this means.

The result of the Researches upon the fossil bones of land animals has demonstrated those changes still more incontestably than the examination of the remains which have been left by the inhabitants of the ocean; both because, as they must have lived on dry land, their being found in strata deposited by water proves that water has covered parts of the continent formerly dry, and also because, their species being fewer in number and better known, we can now certainly tell whether or not the fossil animal is the same with any still living on the globe. Now of the one hundred and fifty quadrupeds examined by Cuvier, and whose remains are found deposited in different strata of our continent, more than ninety are at present wholly unknown in any part of the world; nearly sixty of these are of genera wholly unknown, the rest being new species of existing genera; only eleven or twelve are so like the present races as to leave no doubt of their identity, or rather of their osteology being the same; while the remaining fifty, though resembling in most respects the existing tribes, as far as the skeletons are concerned, may very possibly be found, on more close survey, and on examining more specimens, to differ materially even in their bones. Nor is it at all unlikely that, of the whole one hundred and fifty, every one would be found to be of a race now extinct, if we could see their softer parts as well as their bones and their teeth. But the relation which these different species of ancient animals bear to the different strata is still more remarkable and more instructive in every point of view.

In the *first* place, it appears that oviparous quadrupeds, as crocodiles and lizards, are found in earlier strata than those containing viviparous ones, as elephants and others. The earth which they inhabited must, therefore, have existed and been watered by rivers before the chalk formation, because they are found under the chalk in what is termed the Jurassic formation.—But, *secondly*, among the strata subsequent to the chalk formation, the unknown genera of animals, palæotheria, anoplotheria, are only found in the series of beds immediately over the chalk. A very few species of known genera of viviparous quadrupeds are found with them, and also some fresh water fishes.—*Thirdly*. Certain extinct species of known genera, as elephants, rhinoceros, are not found with those more ancient animals of extinct genera. They are chiefly found in alluvial earth, and in the most recent tertiary strata, and all that we find with these extinct species are either unknown, or of more than doubtful identity with any now existing. Again, those remains which appear identical with the known species are found in recent alluvial earths, and places which seem to belong to the present world.—*Fourthly*. We have seen that the most ancient secondary strata contain reptiles and no other quadrupeds. None of the rocks at all contain any human remains; nor were any remains of the monkey tribe, *or any* of the family of quadrumanes found in Cuvier's time, if indeed they are observable even now. In turf-bogs, in rents and cavities, under ruins as well as in cemeteries, human skeletons are from time to time found; but not a vestige of them or of any human bone in any of the regular strata, or of the fissure deposits, or of the caves and caverns which abound with all the other animal remains. Whatever human bones have been found, were undoubtedly placed there by human agency in recent times.

For Cuvier has examined with the utmost care all the instances which were pretended to afford proofs of human remains. He closely investigated several thousands of the bones in the Paris Basin, and in the deposits of Provence, Nice, and others. All which had ever been supposed to be human he found to be either animal bones, or bones of men accidentally placed among the others, or in some other manner satisfactorily accounted for. The skeleton supposed by Scheutzer to be a man's, and which he made the subject of his book 'Homo Diluvii Testis,' a century ago, has been already adverted to. Cuvier undertook the complete examination of it. The first skeleton which formed the subject of Scheutzer's argument was found near Amiens. Thirty years afterwards another was discovered, but its possessor, Gesner himself, raised grave suspicions that it was some lower animal's remains. A more complete one than either was afterwards found. Cuvier has engraved this, together with Scheutzer's copied from his own book—and how any person could, upon the bare inspection, ever have conceived that either was a human skeleton is truly incomprehensible. But Cuvier has further engraved a land salamander, whose osteology he had, after his admirable manner, thoroughly examined, and its likeness to the fossil remains shows it to be of the same genus, though of a wholly new species, above six times larger. He enters at large into the details of the difference between these remains and the human skeleton. But a further demonstration of their nature was reserved for him when, in 1811, at Leyden, he had access to the actual fossil itself of Scheutzer, and was permitted to remove a portion of the incrusting stone. He did this with the salamander by him, and predicted the kind of bones that would be discovered by the operation. The success of the experiment was complete; and to show the difference between this skeleton and a human subject, Cuvier had the satisfaction of also discovering a double row of small and sharp teeth, studding the fringe or border of the large circular mouth. In 1818, he had an opportunity of repeating this examination upon the last found specimen, which is now in the British Museum, and with exactly the same result. It is therefore demonstrated, as clearly as any fact in the whole compass of physical science, that these bones belong to a race wholly different from the human species, and indeed from any species now existing on the face of the globe. Finally, places where human bones have for many centuries been deposited with the remains of animals, as the ground under ancient fields of battle, have been examined, and it is found that the one are quite as well preserved as the other, and have not suffered more decay. The importance of establishing the conclusion that no human remains are to be found in the strata of the earth will presently appear, and is the reason why we have dwelt upon the evidence in some detail.

If we next inquire at what period the last great change took place, although of course no records can remain to fix it, yet we have some data on which to determine the limits of the question. The progress of attrition in the larger rivers, as the Dnieper and the Nile, and also the formation of downs where they approach from the sea, has been observed, as on the coast of the Atlantic in the south of France; and the results indicate no very remote antiquity as the age of the present terraqueous distribution; certainly not more *than* 5,000 or 6,000 years. Of these, history only goes back about 3,000. Homer lived but 2,800 years ago. Genesis cannot have been written earlier than 3,300 years back. Even the earliest Chinese monuments that are authentic reach but 2,255 years. The astronomical remains of the East, when closely examined, especially the Zodiac, prove nothing of that extreme antiquity which was at one time ascribed to them. Nor do the mines, such as those of Elba, from which similar inferences were formerly deduced, show, since their more accurate examination, anything of the kind. Indeed none of the conclusions they lead to can be regarded as at all of a certain kind. The general result of the inquiry, then, is, that at a period not more remote than 5,000 or 6,000 years ago, a mighty convulsion covered with the ocean all those parts of the globe then inhabited by man and the other animals his contemporaries, and left dry those other portions of the earth which we now inhabit. The few remains of the races then destroyed have served to people this new world; it is only since this period began that we have entered upon the progressive state of improvement in which our race has advanced; and to this period whatever historical monuments we possess of the globe or its inhabitants are confined. But it is equally clear that this inhabited earth, then left dry for the last time, had previously undergone several revolutions, and had been alternately dry land and covered with the ocean, more than once, or even twice, before this last revolution. We have access more particularly to examine the condition and population of the earth when it was last inhabited, that is, when the sea left it the last time but one. We are now living in the fourth era or succession of inhabitants upon this earth. The first was that of reptiles; the second that of palæotheria; the third of mammoths and megatheria; and it is only in this present or fourth era in succession that we find our own species and the animals which have always been our companions.

We are entitled then to affirm that, with respect to animal life, three propositions are proved, all of great curiosity, and still more, when taken either separately or together, all leading to conclusions of the highest importance—

First—that there were no animals of any kind in the ocean which deposited the primary strata, nor any on the continent which that ocean had left dry upon its retreat;

Secondly—that the present race of animals did not exist in the earlier successive stages and revolutions through which the globe has passed;

Thirdly—that our own species did not exist in those earlier stages either.

Now the conclusion to which these propositions leads, and which indeed follows from any one of them taken singly, but still more remarkably from the whole, and most especially from the last, is that a creative power must have interposed to alter the order of things in those early times. That an interposition of this kind took place, the last and most important, about 6,000 years ago, is highly probable from the physical and natural evidence alone which is before us, and to which alone in this work reference can be made. But the date is not material. If at an uncertain period before the present condition of the earth and of its inhabitants, there were neither men nor the present race of creatures, wild and domestic, which people the globe, then it follows that between that period, whensoever it was, and the earliest to which the history of the world reaches back, an interposition of power took place to create those animals, and man among the rest. The atheistical argument, that the present state of things may have lasted for ever, is therefore now at an end. It can no longer be affirmed that all the living tribes have gone on from eternity continuing their species; and that while one generation of these passed away and another came up in endless and uninterrupted succession, the earth abided for ever. An interruption and a beginning of that succession has been proved. The earth has been shown not to have for ever abode in its present state; and its inhabitants are demonstrated, by the incontrovertible evidence of facts, to have at one time had no existence. Scepticism therefore can now only be allowed as to the time and manner of the creative interposition; and on these the facts shed no light whatever. But that an act of creation was performed at one precise time is demonstrated as clearly as any proposition in natural philosophy, and demonstrated by the same evidence, the induction of facts, upon which all the other branches of natural philosophy rest.

It is wholly in vain to argue that the sea or the earth, or the animals formerly existing and now extinct, or any other created beings, or any of the powers of nature, as we know it, or as it has ever been known, could have made the change. It is difficult enough to conceive how these known forces could ever have destroyed the earth's former inhabitants. But suppose the approach of some comet or other body at different times produced the vast tides by which the land was successively swept, this will not account for new species and new genera of living creatures having sprung up both to inhabit the land and to people the waters. An act of creation—that which would now be admitted as a direct interposition of a superior intelligence and power—must have taken place. This is the sublime conclusion to which these Researches lead, conducted according to the most rigorous rules of inductive philosophy, precluding all possibility of cavil, accessible to every one who will give himself the trouble of examining the steps of the reasoning upon which they repose, and removing doubt from the mind in proportion as their apprehension removes ignorance. It is an invaluable addition to the science of Natural Theology, and forms a chapter as new in kind as any of the new animal species are in Natural History.

Such are the benefits conferred upon the great and fundamental argument of Divine Intelligence and contrivance by the recent discoveries in Fossil Osteology. The evidence of design in the combination and mutual adaptation of the parts of extinct animals we pass over as only a multiplication of proof sufficiently numerous before. But the other branch of Natural Theology, that which investigates the Divine Benevolence, also derives aid from this new quarter. We now refer to the argument maintained in the Dissertation upon the Origin of Evil,* and also to the theories which were there very respectfully considered, and diffidently and reluctantly found to be unsatisfactory. The late interesting discoveries have thrown new light upon both these subjects of discussion, and the authors of some of the systems which we examined may appear to the improved state of our knowledge respecting the Chain of Being, as we certainly do make our appeal to it upon what appears to be a more solid ground of argumentation.

The doctrine respecting the Chain of Being is admitted to be incomplete as regards the matter of fact, inasmuch as we find many and large blanks in the series of animated creatures known upon our globe. Whatever other objections, therefore, were competent against this theory, an additional one was, that little appearance of a Chain of Being seems discernible in the universe. Now, the supporters of this doctrine have certainly a right to maintain that the blanks are filled up in a very remarkable manner by the recent discoveries. For the new species of animals discovered to have existed in former states of the globe, unquestionably fill up some of the most remarkable chasms in our series of living animals. Thus the chief blank was always observed in the pachydermatous animals, the fewest in number, the least approaching one another,

* See Paley's Natural Theology, with Notes and Dissertations by Lord *Brougham* and Sir Charles Bell. 3 vols.

and the whole tribe the most removed from others. Now most of the new and extinct kinds of quadrupeds belong to this class, and we have had occasion to observe how links are supplied between race and race hitherto appearing altogether distinct.

But although we may not be justified in reposing great confidence in the argument drawn from the plan of a Chain of Being as applied to the subject of positive evil, there is another point of view in which the subject may, with perfect safety, be considered. As far as regards mere defect, mere imperfection, it is most important to consider whether the plan of Divine Providence may not have been to create a succession of beings rising one above another in attributes; say merely of intelligent beings thus differing in their approaches to perfection. The importance of this consideration cannot fail to strike the observer when he reflects that there is no possibility of separating one of the greatest of all positive evils, death itself, from mere defect or imperfection, as was observed in the Dissertation already referred to; not to mention many other kinds of evils arising from mere imperfection,—as all that proceed from weakness, from ignorance, from defect of mental energy, as well as mental perspicacity. All these evils, and all their various consequences, originate in mere defect or imperfection. Therefore it is of no little moment in this important argument that we should be able to derive any new light to guide our steps upon that part of the ground which belongs to defect or imperfection.

Now the late discoveries certainly afford us some such lights. They show as plainly as the evidence of facts can show anything, that there was a time when this globe existed with animals to people it, but without any beings at all of the human kind. The sounder opinion certainly is, that there has been a succession of stages through which the earth has passed, with different races of animals belonging to each period, that in the earliest age of all no animal life existed; that this was succeeded by another in which reptiles were found to flourish, and that subsequent periods were marked by other successive races of animated beings. But as this is the subject of controversy, we shall only say that there have been two eras, one in which inferior animals only existed without man, and the other in which we now live, and in which our species are the principal inhabitants of the globe. This is admitted by all who have considered the evidence; and they who the most strenuously deny the other doctrines of Fossil Osteology avow their implicit belief in the great proposition, that the relics of an age are clearly discovered in which man had no existence.

Now this position is most important with a view to our present argument. It appears that there was a time when the Creator had not brought into existence any being above the rank of the lower animals. It follows that the divine wisdom had not then thought fit to create any animal endowed with the intelligence and capacity and other mental qualities of the human species. If an observer had been placed in that world, and been called upon to reason regarding it, what would have been his reflections on the imperfections of animated nature? Yet, after a lapse of some ages, those defects are all supplied, and a more accomplished animal is called into existence. The faculties of that animal, and his destinies, his endowments and his deficiencies, his enjoyments and his sufferings, are now the subjects of the observer's contemplation and of his reasoning. What ground has he now for affirming that a more perfect creature may not hereafter be brought into existence—a creature more highly endowed and suffering far less from the evils of imperfection under which our race now suffers so much? No one can tell but that as many of the former inhabitants of the globe are now extinct—tribes which existed before the human race was created—so this human race itself may hereafter be, like them, only known by its fossil remains; and other tribes found upon other continents, tribes as far excelling ours in power and in wisdom as we excel the mastodon and the megatherium of the ancient world.

It is to be further observed that no uncreated being can, by the nature of the thing, have any right to complain of not being brought into existence earlier. The human race cannot complain of having come so late into the world; nor can any of the tribes created before us complain that they were less perfect than a species, the human, which did not then exist. Have *we*, then, the inhabitants of the present world, any better reason to complain that the new, as yet unknown, possible creatures of a future period of the universe have not as yet come into existence? It must be confessed that the extraordinary fact, now made clearly and indisputably* known to us, of a world having existed in which there were abundance of inferior creatures, and none of our own race, gives us every ground for believing it possible that Divine Providence may hereafter supply our place on the globe with another race of beings as far superior to ourselves as we are to them which have gone before us. But how inconceivably does this consideration strengthen and extend the supposition broached in the Dissertation upon Evil! How strikingly does it prescribe to us a wise and wholesome distrust of the conclusions towards which human impatience is so prone to rush in the darkness of human ignorance! How loudly does it call upon us to follow the old homely maxim, "When you are in the dark, and feel uncertain which way to move, stand still!" How forcibly does it teach us that much—nay, that all which now we see as in a glass darkly, and therefore in distorted form and of discoloured hue, may, when

* The kind of controversy which may be raised, but never has been raised on this point, is discussed in the next dissertation.

viewed in the broad and clear light of day, fall into full proportion and shine in harmonious tints!*

It would be improper not to mention at the close of this Analytical View, that the science of Palæontology

* Dr. Paley, in his twenty-fifth chapter, assumes, that whenever a new country has been discovered, with new plants and animals, these are always found in company with plants and animals which are already known, and possessing the same general qualities. From hence he derives an argument for the unity of the First Cause. Mr. Dugald Stewart also infers from the supposed identity of animal instincts in all ages, that the laws of physical nature must have always been the same, otherwise these animals could not have continued to exist

Now, *first* as to Dr. Paley's assumption. It certainly appears too large, even as regards the existing species and the present state of the globe; for there seem to be some places where all the animals are peculiar. But be that as it may, the fact assumed is by no means necessary for the support of Dr. Paley's conclusion in favour of the Divine Unity. It is extremely probable that in some former stages of our globe there were no animals whatever of the same tribes with those which to us are familiarly known. Yet can there be any doubt that in their structure the same degree of skill is observable as far as their only remains enable us to judge, and can we hesitate to believe, that were there other parts before us, we should in those find as much artistlike contrivance as in the existing races of animals? Indeed we may go farther and assert, that there is every ground for supposing that the same kind, as well as an equal measure of skill, is to be traced in the lost as in the existing tribes, and that, consequently, the characteristic argument will equally apply here. The proof of this in the structure of the alimentary canal, which Cuvier was not acquainted with, will presently be considered.

Secondly. With respect to the observation upon instinct, unquestionably some doubt may be raised by the new discoveries; for we cannot feel any confidence in the assertion that the animals, whose skeletons alone remain, were endowed with instincts similar to those now in being, more especially the tribes of anomalous description, such as the pterodactylus and ichthyosaurus. We have never seen in life any animals combining the various forms which seem to have met in these extraordinary creatures. We cannot, therefore, feel entire confidence in the belief that their habits or instincts resembled those of any combination of animals so dissimilar,—still less can we comprehend a harmonious union of the instincts proper to birds with those peculiar to reptiles, which yet the pterodactyli seem formed to obey. Dark, however, as is this department of the subject, we have abundant ground, from the preponderating weight of analogy, for resting satisfied that all their instincts, whatever they may have been, were nicely adjusted to their bodily powers, and that both their bodies and their instincts were as nicely adapted to the laws of matter and of motion.

was much indebted to some able and learned men who were contemporaries of Cuvier. The examination of the Paris Basin, as regards its mineral character, was almost wholly the work of Brongniart, and it is allowed to be a model in that kind. Cuvier's brother, also, ably assisted him in the botanical department. The labours of Lamarck in conchology are so universally known as to need no further mention; and among other names may be stated that of Miller of Bristol, as having made valuable contributions to these inquiries.

LABOURS OF CUVIER'S SUCCESSORS.

Many learned men were attracted by the discoveries of Cuvier, and devoted themselves to the cultivation of the same science. During the last twelve or fifteen years of his life they had joined in similar pursuits, and many of his opinions were modified, and many of his researches were materially aided, by their diligent and successful inquiries. As far as regards the general connexion between Organic Remains and Geology, indeed another inquirer had appeared in the field as early as himself, the laborious, modest, and sagacious William Smith, a civil engineer, who, unassisted and almost unknown, had been prosecuting his researches into the mineral state of England, and performed certainly the most extraordinary work that any single and private individual ever accomplished—the delineation of the strata of the whole country, in a set of underground maps, which he published in 1815, and followed afterwards with a work upon the relation between these strata and their Organic Remains. Although the results of his investigations were published thus late, he had many years before communicated the greater part of them freely to his private friends. It must be confessed that few men of greater merit, or more unassuming, have ever adorned any walk of science, and few have ever made a more important step in assisting the progress of discovery.

The other able persons who have cultivated this branch of science are certainly endowed with greater learning, that is, book learning, than Mr. Smith could *boast* of, beside attending closely to actual observation in the field. Some of them, too, may fairly claim a high place as men of profound and original views. Where so many excel and prefer claims so undeniable to the gratitude of the world, it is invidious as well as difficult to make a selection, the rather as, happily, we still have the great benefit of their continued assistance. In Italy, Brocchi; in Switzerland, Studer, Hugi, Charpentier, and Agassiz, the able and zealous disciple to whom Cuvier gave up the department of fossil ichthyology, when composing his work on Comparative Anatomy; in Germany, Von Buch, Kaup, Count Münster, Goldfuss, Rosenmuller, Wagner, and the justly celebrated Humboldt; in Russia, Fischer; in Belgium, Burtin, Omalius, Dumont; in France, Beaumont, Brongniart, Blainville, Prevost, Boué, Brochant, Geoffroy; and in England, Conybeare, Mantell, Lyell, Clift, De la Beche, König, Hibbert, Broderip, Fitton, Bakewell, Greenough, Forbes, Owen, Murchison, Sedgwick, and Buckland.* These, it is believed, are all, except Brocchi, fortunately still alive, and still actively engaged in the same interesting inquiries, though some of them rather confine their study to the geological portion of the subject. If from the brilliant assemblage the names of Sedgwick and Buckland were selected, but, as regarding Fossil Osteology, the latter especially, private friendship could hardly be charged with officiously assuming to be the organ of the general voice—but, indeed, to record such merit might well seem presumptuous, where the panegyric is far less likely to reach aftertimes than the subject of its praise.

The labours of Cuvier's successors, as far as regards his doctrines, belong to one or other of three classes: to the progress which they have made in examining the fossil remains of former worlds, or conditions of our

* Written in 1838. Since that period, while we have to deplore the loss of many of the above, a new band of inquirers—Ansted, Ramsay, Phillips, M'Coy, Hugh Miller, D'Orbigny, and others—are rapidly following up the researches of those removed, and daily adding to our knowledge.

globe;* to the arguments which they have advanced in opposition to or in support of his theory respecting the relation that subsists between those animal remains and the strata in which they are found; and to the arguments adduced for or against his opinions respecting the formation and age of those strata. It may be proper to mention the things done under each of these heads, although the last is of comparatively little importance to the purpose of the present work, and the second is of considerably less moment, as regards Cuvier's proper subject, than the first.

I. Among the extinct mammalia of the pachydermatous order, we mentioned one which Cuvier referred to the tapir genus, but pronounced to have been of a gigantic size. He only had seen the jaw teeth of the animal. But since his time other important parts have been found, chiefly at Epplesheim, in Hesse Darmstadt: and a genus *Dinotherium* (having four species) has been established, of which this species is termed *giganteum*, his length having been apparently not less than eighteen or nineteen feet. His distinguishing peculiarity is the having two enormous tusks, which are bent downwards like those of the walrus, but are placed at the front end of the lower jaw, so as to bend below the chin. Dr. Buckland has shown by most cogent arguments that he must have lived chiefly in the water, and these tusks in all probability were used in supporting him, anchored as it were, to the side of the river or lake while his huge body floated, as well as employed in digging for the roots upon which his teeth show that he fed.

Notwithstanding somewhat scanty materials, Cuvier had described and, as it were, restored the megatherium with extraordinary skill. But a further importation of bones from South America has enabled observers in this country to throw some additional light upon the

* The notes to the Analysis of Cuvier contain statements of the numbers of new species discovered since his time.

structure and habits of this singular animal. These bones were found in the bed of the river Salados in Buenos Ayres, a succession of very dry seasons having brought the water unusually low. Mr. Clift, of the Surgeons' Museum, a most learned and skilful comparative anatomist, and pupil and assistant of John Hunter, examined them fully, and found many very singular particulars not before known respecting this animal. Among other things it appears to have a bony partition between its nostrils (septum narium) like the rhinoceros tichorhinus. The structure of its teeth indicates that they are formed by perpetual growth like the elephant's tusks, and not like his teeth by renewal. The enormous size of the tail never could have been conjectured from the analogy of the elephant and other pachydermatous animals. It was composed of vertebræ, of which the one at the root had a diameter of seven inches, and the diameter from the extremities of the processes was no less than twenty-one inches. If then allowance be made for the muscle and integuments, it could not have been less than two feet in diameter at the root, and six feet in girth. There can be little doubt that it was used both as a weapon of defence and to support the animal in conjunction with part of his large feet, while the others were employed in digging or scraping away the earth in quest of his food. The fore feet were a yard long, and the bones of the fore legs were so constructed that the limb could have a lateral or rotatory horizontal movement for the purpose of shovelling away the soil. The bone of the heel is also of extraordinary length. The proportion of his bones to those of the elephant is very remarkable. The first caudal vertebra in the megatherium being twenty or twenty-one inches, in the elephant it is barely seven. The circumference of the thigh in the former is two feet two inches, in the latter one foot. The expanse of the os illii in the former no less than five feet one inch, in the latter three feet eight inches. The bony cover of the hide has also been now more fully examined. It was about an inch in thickness, and so hard as to resist all external violence. The cumbrous movements of this unwieldy creature exposing it to many kinds of danger, the hide served to defend it from some enemies, and the weight and strength of its limbs and tail enabled it to destroy others; escape from any by flight being quite impossible. Mr. Clift informs me that he has found in the region of the pelvis small lumps of adipocire. So that we have here an additional instance of the softer parts of an extinct animal still preserved in a state to which flesh is now often reduced by decomposition in water.

Mr. Darwin (grandson of the celebrated physician and poet) has found in South America many interesting remains. Among these are the bones of an edentate, between the megatherium and armadillo (largest kind); those of a huge rodent in size equal to the hippopotamus; and those of an ungulate quadruped the size of a camel, and forming the link between that class and the pachydermata.

In the lias stratum of Lyme Regis there was found in 1828, by Miss Anning (to whose skill in drawing, as well as her geological knowledge, Cuvier often acknowledges his obligations), a new species of pterodactylus with very long claws, and hence Dr. Buckland gave it the name of *Pter. Macronyx*. It appears to have been the size of a raven.

In 1824, Mr. Mantell discovered in the Tilgate sandstone, in Sussex, the remains of an herbivorous reptile allied to the iguana genus, but vastly larger; and he gave it the name of *Iguanodon*.* Other parts of the animal has since been found in different places, as in Purbeck, and in the Isle of Wight. Mr. Murchison found a thigh bone three feet seven inches long; and in 1829, a metacarpal bone, of six inches long by five

* This discovery had been made before the last edition of Cuvier's book, and is mentioned, though shortly, in the Analysis.

wide, was found in the iron sand, and a vertebra as large as an elephant's. The opinion of Cuvier referred the large thigh bone clearly to Mr. Mantell's reptile, whose dimensions must therefore have been enormous, though it was not carnivorous.

In 1834, a large proportion of the skeleton was found in the Rag quarries near Maidstone. This confirmed all the previous conjectures as to the bones separately discovered. The length of this monstrous reptile is calculated to have been seventy feet from the snout to the tip of the tail, the tail to have been fifty-two feet long, and the body fourteen feet round.* Mr. Mantell also discovered in 1832, in Tilgate Forest, the remains of a lizard, which may have been twenty-five feet long, and was distinguished by a set of long, pointed, flat bones on its back, some rising from it as high as seventeen inches in length. He called it *Hylæosaurus*, from being found in the Weald.

There were found in 1836, a great collection of fossil bones in the department of Gers, in France, in a tertiary fresh water formation. Above thirty species, all mammalia, were traced, and of these the greater part were new extinct animals, but all were of extinct kinds; two species of the dinotherium; five of the mastodon; a new animal allied to the rhinoceros, and another to the anthracotherium; a new edentate; and a new genus between the dog and racoon; but the most singular and new of the whole is the under jaw of an ape, which appears to have been thirty inches in height. But we must be very cautious in giving our assent to this, until we are better informed of the position where the jaw was found. It is certainly possible; but after the history of the Guadaloupe skeleton, clearly human, as clearly found among fossil remains, but now universally admitted to have been a recent deposit, we may pause before concluding that a deposit contrary to all other

* Geol. Trans., N. S., vol. iii., pt. 2.

observations of fossil bones should have occurred in any tertiary formation.*

In the time of Cuvier, at least before the completion of his great work, our knowledge was so scanty of the fossil osteology of the East, that we doubt if any allusion to it is ever made by him. Three most important contributions to this branch of science have since extended our knowledge in that direction, and a rich addition may soon be expected from Mr. Clift's labours upon a large recent arrival.

The first was by my excellent friend Mr. Craufurd, who, travelling in the Burman empire, was fortunate enough to discover a great number of fossil remains near the river Irawadi. These he generously gave to the Geological Society, and Mr. Clift proceeded to examine them with his wonted assiduity and skill. Among them were traced two new species of mastodon, in addition to the *M. gigas*, and *M. angustidens*, of Cuvier. One is termed by Mr. Clift, *Latidens*, from the breadth of his jaw teeth; and the bones of his face exceed in size those of the largest Indian elephant. The other he calls *M. Elephantoides*, because his teeth approach much nearer the elephant's than those of Cuvier's species, or of the Latidens. This animal appears to have been smaller than the elephant. A hippopotamus smaller than the living animal, a rhinoceros, a tapir, and others, have also been traced among these remains, as have a new lizard near the garial, and a crocodile near the common animal.†

The second of these discoveries was made on the north-east border of Bengal, at Carivari, near the Brahmaputra river. The remains were examined by Mr. Pentland. He traced a new species of anthraco-

* I have lately seen an appearance of a stratum of calcareous matter, which a cursory observer would certainly have supposed to be a natural deposit in the ground; but its history was known from some rubbish through which lime had filtered, when part of Buckingham House was *built*, and there were bricks, tiles, &c., underneath it.

† *Geol.* Trans., N. S., vol. ii., pt. 3.

therium, which he calls *Silicestre*, a new carnivorous animal of the weazel tribe, and a pachydermatous animal much smaller than any hitherto known, either living or fossil.*

The third and most remarkable of these collections is one discovered in the Markanda valley, and the Sivalik branch of the Himalaya mountains, in the year 1835. The curiosity of naturalists in India was immediately roused, and their industry directed towards the subject with that ardour which the relaxation of a sultry climate never abates, and that combined perseverance and ability which has ever marked the great men of our Eastern settlements. Dr. Falconer and Captain Cautley have chiefly signalized themselves in this worthy pursuit; valuable aid has likewise been rendered by Lieut. Durand; and the result of their labours occupies one-half of the 'Asiatic Researches for 1836.' They found first of all a new animal, of the ruminating class, whose skull is the size of a large elephant's, and which has two horns rising in a peculiar manner from between the orbits, with an orifice of great breadth and an extraordinary rising of the bones of the nose. They gave it the name of *Sivatherium*, from the place of its discovery, dedicated to the deity Siva. The breadth of the skull is twenty-two inches. Dr. Buckland has no doubt that it must have had a trunk, something intermediate between the elephant's and tapir's. They next found a hippopotamus of a new species, distinguished by having six incisive teeth, and a skull materially different from the other species, whether living or extinct. A new species of tiger was also discovered, which they called *Felis Cristata*, distinguished chiefly by the great height of the occipital bone. In the same place with these bones were found remains of the mastodon, and other known species of extinct animals; but the most interesting discovery was

* Geol. Trans., N. S., vol. ii., pt. 3.

that of a camel, of which the skull and jaw were found. It is to be observed that no decisive proof of any of the Camelidæ, either camel, dromedary, or llama, had ever been hitherto found among fossil bones, although Cuvier had proved certain teeth brought from Siberia to be undoubtedly of this family, if they were really fossil, which he doubted. This discovery in India was therefore extremely interesting, as supplying a wanting genus. But for this very reason it became the more necessary to authenticate the position of this supposed camel's remains the more clearly, especially as there were abundance of existing camels in the country, which there could not be in Siberia. The Indian account is somewhat deficient in this respect, leaving us in doubt whether the bones admitted to bear a very close resemblance to the living species, were found in a stratum, or loose and detached.*

Besides all these additions to our knowledge of species and genera, two remarkable observations or sets of observations have been first made by osteologists since the time of Cuvier. The one of these is the tracing of footsteps, the print of which has been left by animals upon the sand, or other material of the strata, while in a soft state. The other is Dr. Buckland's study of the intestines from their fossil contents, which he has called *coprolites*.† The first of these curious inquiries is conducted by observing the impressions which the softer and more destructible parts of animals, whose very race has been extinct for ages, made upon the earthy strata of a former world; it is the object of the other inquiry to ascertain from the petrified fæces bearing the impress of the alimentary canal, the internal structure of extinct animals; and both subjects are certainly calculated powerfully to arrest our attention.

* *Asiatic Researches*, vol. xix. pt. 1.—Still more recently, it is said, a bone of the genus Simia has been found in the Sivalik Hills, and another *in digging* at Calcutta; but the particulars are unknown to me.

† Κοπρος, fæces; λιθος, stone.

The footsteps, it appears, were first observed by my reverend and learned friend, Dr. Duncan (to whom the country is also so deeply indebted as the author of savings banks), in Dumfriesshire. On examining a sandstone quarry, where the strata lay one over the other, or rather against the other, for they had a dip of forty-five degrees, he found these prints not on one but on many successive layers of the stone; so that they must have been made at distant periods from each other, but when the strata were forming at the bottom of the sea. No bones whatever have been found in those quarries. Similar impressions, though of smaller animals, have been observed in the Forest marble beds near Bath. The marks found in Dumfriesshire, of which there were as many as twenty-four on a single slab, formed as it were a regular track with six distinct repetitions of each foot, the fore and hind feet having left different impressions, and the marks of the claws being discernible. They appear to have been made by some animal of the tortoise kind.* But similar marks have since been found in other parts of the world. At Hessberg, in Saxony, they have been discovered in quarries of grey and red sandstone alternating; the marks are much larger than those in Scotland, and more distinct. In one the hind foot measures twelve inches in length, and the fore foot is always much smaller than the hind. From this circumstance, and from the distance between the two being only fourteen inches, it is conjectured that the animal was a marsupial, like the kangaroo. But one of the most remarkable circumstances observed is, that the upper stratum has convex marks answering to the concavity of the lower slab on which it rests, clearly showing that the former was deposited soft after the latter had been first printed by the foot in a soft state and then somewhat hardened. Dr. Kaup has termed the large unknown animal *Chiro-*

* Edin. R. S. Trans., 1828.

therium,* from the supposed resemblance of the four toes and turned-out thumb to a hand. In the summer of 1838 similiar footsteps of the chirotherium, and of four or five small lizards and tortoises, with petrified vegetables of a reedy kind, have been observed in the new red stone at Storeton Hill quarry in Cheshire, near Liverpool. A discovery has within the last two years been made in the state of Connecticut, near Northampton, where the footsteps of various birds, differing exceedingly in size, are found in inclined strata of sandstone, and evidently made before it assumed its present position. The marks are always in pairs, and the tracks cross each other like those of ducks on the margin of a muddy pond. One is the length of fifteen or sixteen inches, and a feathery spur or appendage appears to have been attached to the heel, eight or nine inches long, for the purpose of enlarging the foot's surface, and, like a snow-shoe, prevent the animal's weight from sinking it too deep. The distance between the steps is proportioned to their length, but in every case the pace appears to have been longer than that of the existing species of birds to which they approach nearest, the ostrich. Consequently, the animal must have been taller in proportion to his size. How much larger he was than the ostrich may be gathered from this, that the large African ostrich has only a foot of ten inches long, less than two-thirds of this bird, and yet stands nine feet high. These proportions would give a height of fourteen feet to the extinct animal. Some of the footsteps in the Storeton Hill quarry are eighteen inches in length. In the Forest marble of Bath the footmarks of small marine animals are descried.

In examining the inside of the ichthyosaurus, the half-digested bones of the animals on which these ravenous creatures preyed are found in large masses. But there are also scattered in great abundance among

* Χεὶρ, hand.

their fossil remains the fæces which they voided; and these being in a petrified state have preserved the very form of the intestines in minute detail. The fæcal matter is generally disposed in folds, wrapt round a central axis spirally. Some of these coprolites exhibit the appearance of contortion, and show that the intestines of the animal were spirally twisted; others, especially the smaller ones, give no such indications. The scales and bones of the prey are distinctly to be traced in the mass; these are the remains, undigested, of contemporary fishes and reptiles, including smaller ones of the beast's own tribe, on which he appears to have fed, as well as on other species. The light which these coprolites throw upon the structure of the animal's intestinal canal is sufficiently remarkable. The intestines are proved to have been formed like an Archimedes screw, so that the aliment in passing through was exposed within the smallest space to the largest surface of absorbent vessels, and thus drained of all its juices, as we find in the digestive process of living animals. The similar structure of the intestinal canal in the sharks and dogfish now existing has been noticed by naturalists; and Dr. Paley expressly refers to it as making compensation by its spiral passage for its being straight, and consequently short, compared with the intestinal passage in other animals. We also can distinctly trace in these coprolites the size and form of the folds of the mucous membrane that lined the intestines, and of the vessels which ran along its surface. As there is no part of the animal frame more easily destructible than the mucous membrane and its vessels, the preservation of its casts is certainly a peculiar felicity for the physiologist. Similar observations have, since Dr. Buckland's discovery, been made upon the coprolites of fossil fishes, in the Lyme Regis lias, in Sussex, in Staffordshire, and near Edinburgh. In some places they take so fine a polish that lapidaries have used them for cutting into ornamental wares. One of the most singular coprolites was found by Lord Greenock (an assiduous and successful cultivator of natural science) between the laminæ of a block of coal near Edinburgh, and surrounded with the scales of a fish recognized by Professor Agassiz as of contemporary origin. To these observations a very curious addition has been made by the Professor, who found that the worm-like bodies described by Count Münster, in the lithographic slate of Solenhofen, are in fact the petrified intestines of fishes, and he has also found the same tortuous bodies occupying their ordinary position between the ribs in some fossil remains. He has named them *Coleolites*;* and certainly the representation given of them in the drawing resembles an actual intestine as accurately as if it were the portrait of it.

When Cuvier abandoned to Professor Agassiz the whole department of Fossil Ichthyology, he showed as happy and just a discernment of living character as he ever displayed in the arrangement and appropriation of animal remains. That admirable person has amply earned the honour thus bestowed on him by devoting his life to this extensive, obscure, and difficult study. The results of his laborious researches have been from time to time published in a great work upon fossil fishes; but as the arrangement followed as yet in the publication necessarily leaves the several parts incomplete, a distinct and satisfactory view of the whole cannot be formed until the work is finished. Some of the discoveries, however, which bear upon the subject of our present inquiries may be shortly described. The importance of the study to fossil geology is manifest from this, that the class of fishes being continued through the successive periods of the different formations, while those of land animals are confined each within certain limits, and the fishes being also inhabitants of those waters in which all the aqueous deposits

* Κωλον, the great intestine.

once were contained, we are enabled by Fossil Ichthyology, through various periods of the earth's formation, to pursue the comparison of a vertebrated animal's condition in each stage.

The Professor's classification is founded upon the form of the scales, which are adapted to the structure of each tribe, and afford a perfectly scientific principle of arrangement. He thus divides the whole into four orders:—the *Placoïdeans,** whose scales are irregular enamel plates more frequently broad, but varying in dimensions down to a point or prickle; the *Ganoïdeans,*† with angular scales of bone or horn thickly enamelled and shining; the *Ctenoïdeans,*‡ with comb-like scales having a jagged edge and no enamel;§ the *Cycloïdeans,*‖ whose scales are smooth at the edge, and composed of horn and bone, but unenamelled.¶

There were in all 8,000 species of fish enumerated by Cuvier, of which more than three-fourths, or 6,000, belong to the two last classes, and no one of either of these classes has ever been found in any formation anterior to the chalk; so that the whole of these 6,000 kinds of fish have, to all appearance, been called into existence at a period long after the primitive, the transition, and all but the latest secondary formations. On the other hand, and in the earlier times of the secondary and transition strata, there existed species of the other two orders, which have comparatively few representatives surviving to our days. The Professor has thoroughly examined 800 fossil species of these two orders, and finds not a single exception to the rule thus laid down for the relation between different species of animals and successive formations of strata.** His deductions received further corroboration by the examination of 250 species, all of new and extinct

* Πλαξ, a tablet or plate. † Γανος, brilliancy.
‡ Κτεις, a comb. § Perch belong to this class.
‖ Κυκλος, a circle. ¶ Salmon and herring are of this class.
** Rapport sur les Poissons Fossiles, 1835, p. 38.

fishes, submitted to him in England, and which were, for the most part, found in this country. The analogy in this respect between the results of Fossil Ichthyology and those of Cuvier's Researches is striking throughout. In the lower deposits of the lias there are found the remains of the great sauroïd fishes analogous to the fossil lizards of the same strata. More than two-thirds of the fishes found in the chalk strata are of genera now extinct. These extinct genera, however, of the newest secondary strata approach more nearly to the fishes of the tertiary strata than the fishes found in the oolite or Jurassic formation; insomuch that the Professor is disposed to range the chalk and greensand nearer to the tertiary than secondary formations on this account. Not a single genus even of those whose species are found in the Jurassic deposits is now known among existing fishes; nor is there a single species, and but few genera common to the chalk, and the older tertiary strata. A third of those found in the strata of the later tertiary formation, as the London clay and the coarse limestone of the Paris Basin, are of extinct genera. The Norfolk crag and upper subappenine formation have, for the most part, genera found in the tropical seas; the tertiary formation generally approaches nearest to our living species, but the Professor affirms that, except one small fish, found in modern concretions on the coast of Greenland, not a single species exactly the same with those of our seas is to be found in a petrified state. This continued analogy is very important in a geological view.

In a zoological view it would be endless to attempt any analysis of the Professor's researches. Among the extinct species no less than 150 belonged to the family of sharks, whose services, in keeping down the increase, naturally so rapid, of fishes, have been required in all ages of the ocean. Different kinds of shark, however, appear to have belonged to different periods. Of the three sub-families into which the

Professor divides the great class of sharks, the first is found in the earliest period of organic remains, the transition strata, and continues till the beginning of the tertiary, but there is now only one species of it existing, and that is found in New Holland. The second sub-family begins probably with the coal formations, and ceases when the chalk commences. The third begins with the chalk, and continues down through the tertiary formation to the present time. The form as well as the size of the extinct species differ in most things materially from the living, and in no respect do they vary more than in their covering or scales.

As the coprolites enable us to ascertain the interior structure of the extinct reptiles, so do they throw light upon that of fishes also, those especially of the sauroïd or lizard-like kind. We have even instances of their intestines being partially preserved by some fortunate accident. An example near Solenhofen has been mentioned already. A specimen was found in Sussex, where the stomach, with its different membranes, was retained. In a number of fishes found in the Isle of Sheppy the bony capsule of the eye was found entire; and in some other instances the plates forming the gills or branchiæ are perceivable.

It thus appears that great and important additions have been made to this interesting science since Cuvier, who may properly be termed its founder, ceased from his labours. But it would not be proper to pass from a consideration of the services rendered by his successors, without making mention of one illustrious inquirer, a man of truly original genius, who preceded him by a few years. John Hunter, whose unrivalled sagacity seemed destined to cast a strong light upon whatever walk of science he trod, had turned his attention, as early as 1793, to fossil bones, in consequence of a collection sent to this country by the Margrave of Anspach. He described and commented upon them in detail with his wonted acuteness; he adopted the same safe and natural course which Cuvier afterwards pursued with such signal success, of examining the known bones of existing species as well as those submitted to his consideration; and it appears, from some of his concluding remarks, that he perceived distinctly enough the specific difference of the fossil animals, at least of some among them. Thus, having compared the fossil skull of a supposed bear with that of a white bear which he had procured from the owner of the animal while alive, he gives an accurate drawing of both, and marks their diversities, indicating his opinion that the fossil animal differed from all known carnivorous animals.* Who does not perceive that he was on the right track, and would have reaped a plentiful harvest of discovery, had he devoted himself to the general investigation of the subject?†

II. The speculations of succeeding zoologists or comparative physiologists have not only made no impression upon the anatomical results of Cuvier's inquiries, but they never appear to have been pointed towards that object. Considering the numberless instances in which he had to draw his conclusions or to form his conjectures from a very imperfect collection of facts, it is wonderful how constantly the fuller materials of his followers have confirmed his inferences. But geological inquirers have occasionally impugned his doctrines respecting the relation of the classes of animals to the successive formations of the strata that incrust our globe. It has been denied by some that any such relation at all can be truly said to exist. There seems, however, no possibility of maintaining this position, whether we agree wholly with Cuvier or not in the detail of his statements. For the fact is undeniable

* Phil. Trans., 1794, p. 411.

† In the Hunterian Museum there is a large collection of fossil organic remains, selected with consummate skill, and showing the attention bestowed by this great man on the most delicate parts of organization which they exemplify.

that some strata, let them have been arranged in whatever succession, formed and placed by whatever causes, contain the remains of certain classes of animals which are not to be found in other strata. It is another fact equally indisputable, that no animals now exist of the same kind with the greater part of those found in any of the strata. This appears to connect the different races of animals with the different strata. But it is said that this is not a chronological connexion, and affords no evidence of strata having been formed rather in one age than another. If it were so, there still would remain a foundation for the position which merely affirms a relation between organic remains and strata. But is it true? The principal reason assigned is, that although no animals of a certain kind are found in certain strata, supposing those strata to have been formed at a given period, the animals of the kind in question may have perished so as not to have been washed into the sea or other water in which the earthy matter was mixed, and from which it was deposited. Now, not to mention that this bare possibility becomes improbable in the degree in which the facts are multiplied and the observations of animals and strata extended, the researches respecting fossil fishes seem to negative the objection entirely. For if the different strata were made by the sea, and contain totally different remains of marine animals, it is clear that each must have been formed respectively in a sea inhabited by different animal tribes. The strict parallelism, too, which is observed between the connexion of different races of animals and that of fishes with different strata, lends the strongest confirmation to Cuvier's doctrines.

Ingenious and laborious attempts have been made to show, that though many races of animals are now wholly extinct, the evidence fails to prove the non-existence of any race (except our own) at a preceding period; in other words, to disprove the proposition that many of the present races came for the first time into existence at a period subsequent to the time when we know that others existed, always excepting the human race, which it is admitted we have sufficient reason to believe did not exist in the earlier stages of the globe's formation. It cannot, however, be denied, *first*, that the extinction of many races of animals, which is admitted, affords a ground of itself for thinking it probable that new ones should be found to supply their places; *secondly*, that there seems nearly as little reason to regard the utter extinction of some classes as more improbable than the formation of others; *thirdly*, that the admitted creation of man destroys the whole support which the objection might derive from a supposed uniformity of natural causes, always acting, and removes the difficulty said to exist, of assuming different sets of principles to be in action at different periods of the world; *fourthly*, that the great number of facts which have been observed, all pointing uniformly in one direction, cannot be got over by suggesting mere possibilities for explanations. The improbability is extreme of one set of animals having existed at the same age with another set, when we find certain strata having the traces of the former without any of the latter, and *vice versâ*. This improbability increases in proportion to the number of the species. If these exceed hundreds, and even amount to many thousands, the improbability becomes so great as to reach what, in common language, we term a moral impossibility. Now, there are 6,000 kinds of fishes, of which not one specimen is to be found in any of the formations preceding the chalk. But suppose we lay out of view all question of one formation being older than another, there are certain strata in which none of those species are found. There is no disposition to deny that these strata were formed in the water; therefore, at whatever time they were suspended in the water, that water at that time contained none of those 6,000 kinds which *now* people it. Then from whence did they all come if they existed at that period, and yet were not in the water when the strata were formed? But it is equally admitted that the water in those days contained many other kinds of fish now extinct, and found only in certain strata, and it contained some few which we find in other strata, and some which are still to be found in the sea. Can anything be more gratuitous than to suppose that all the fishes of a certain class were destroyed at the formation of those strata, while all those of another class were afterwards brought from a different part of the sea to succeed the last ones, and a certain small number survived to mix with other strata, or even to last till now?

The only sound objection that can be taken to the theory, is that to which the absolute assertion of the fact is liable. We can easily ascertain that certain species are no longer to be found living on the globe. But we may not be so well able to affirm with certainty that certain fossil genera of one formation may not hereafter be found in another, or, which is the same fact in another form, that certain living species may not be traced among fossil remains. Thus the small family of the camel was wanting in all our fossil collections till the late discoveries in the Himalaya mountains have made it probable that a species of this class may be found to have existed there with the mastodon and other extinct mammalia. This is possible, perhaps likely. So an ape's jaw is supposed for the first time to have been found in a fossil bed in France with other races, and no quadrumane had ever been before traced in any part of the fossil world. The proof of this discovery is, however, as yet involved in some doubt, and even were it more precise, we should only have two instances in which the negative evidence had failed, leaving a multitude of others, hundreds of land and thousands of sea animals, of which no representatives are to be traced among the fossil remains of any country. It must always be recollected that the whole argument rests upon probability, more or less high. Even as regards the admitted non-existence of the human species, the mere evidence of osteological researches is not demonstrative; for although it is quite certain that among the thousands of animal remains which have been discovered and carefully examined, not a fragment of a human bone is to be found, it is barely possible that in some deposits as yet unexplored the skeleton of a man may be discovered. We have at present only to make our inference square with the facts; to affirm that, as far as our knowledge extends, there is no such relic of our race in the earlier strata of the globe; and to conclude that, considering the extent of past inquiries, the regularity of the connexion between other races of different kinds and various strata, and the portions of the earth over which our researches have been carried the very strong presumption is against any such contradictory discovery being hereafter made.

III. Whatever opinion men may form upon the question raised by some antagonists of Cuvier's geological doctrines, all must allow that considerable light has been thrown upon the subject of discussion by their labours. Indeed a considerable addition to our knowledge has been made by some of these able and learned men, even admitting that they have failed to impugn the theory, and taking the facts which they have ascertained as forming an addition, by no means inconsistent with it. Thus the valuable work of Mr. Lyell has, in two essential respects, greatly advanced geological knowledge. He has examined, with a much more minute attention than had ever before been given to the subject, the action of the physical agents actually at work before our eyes, and has shown how extensively these may operate upon the structure of the earth's surface. It may be admitted, perhaps, that Cuvier had somewhat underrated their power, although the reader may still retain his opinion, that the force ascribed from the facts to those ordinary physical powers is inadequate to produce the effects which the phenomena present; that all the violent and sudden actions known on the globe are topical, being confined within comparatively narrow limits, and that the supposition of sudden and even instantaneous change on a vast scale in former periods has been too lightly taken up. Indeed, unless we suppose such changes as might happen from the disruption of a continent united by a small neck of land, like that which may be found once to have joined Gibraltar and Ceuta, it seems hard to imagine how a tract of country, extending from Holland to beyond the Caspian, and from Scandinavia to the Carpathian mountains, could be drained of the sea, which certainly once covered it, or, having still more anciently been dry, could have been laid under water.*

But a much more important service has been rendered by Mr. Lyell's comparison between the different formations of the tertiary class; and although it is with unavoidable distrust of himself that any one little versed in geological science should venture to speak, it should seem that the division which he has thus succeeded in tracing of the tertiary period, may stand well with the previous system of Cuvier, and be received as a fact independent of the controverted matter with which it has been connected. With the important aid of several eminent conchologists, but especially of Mr. Deshayes, he examined the numbers of testaceous animals traced in different formations; and finding that in some strata the proportion of shells of living species was very different from others, he distributed the strata of this tertiary period into three classes accordingly; the earliest being those which contained the fewest of our living species. The latest of the three periods into which he thus subdivides the tertiary

* In Mr. Whewell's learned work on the History of the Inductive Sciences, there are some acute and important remarks on the two theories, that of Uniform Action, and that of Catastrophes. B. xviii., c. 8.

era he calls *pliocene,** or more recent; the next before *miocene,*† or less recent; the earliest *eocene,*‡ or dawning. Seventeen species of shells are common to the three divisions, of which thirteen still exist and four are extinct. In the pliocene the proportion of existing shells always exceeds one-third, and usually approaches one-half of the whole found. In the miocene, the existing shells fall considerably short of one-half, that is, the extinct species preponderate; indeed, of 1,021 examined, less than a fifth were existing. There are 196 common to this and the last period, of which 82 are extinct. In the eocene period, the proportion of existing shells is much smaller, not exceeding three and a-half per cent.; and there are only 42 common to this and the miocene. In the Paris Basin 1,122 species have been found, of which only 38 are now known as living.

The theory of Cuvier and Brongniart respecting the successive formations in the Paris Basin, appears to require some modification in consequence of more recent examination. They considered that upon the chalk there was laid, first a fresh water formation of clay, lignite, and sandstone; then a marine formation of coarse limestone; and then upon that a second fresh water formation of siliceous limestone, gypsum, and marl. The researches of Mr. Constant Prevost seem to show that instead of these three successive formations, there were laid on the chalk a clay formation of fresh water origin, and then upon that, contemporaneously, three others, in different parts of the same Basin, namely, a fresh water formation of siliceous limestone, another of gypsum, and a marine formation of coarse limestone. In the rest of the series the two theories coincide.

It must, however, be observed that the more important doctrines of Fossil Osteology, even as regards their connexion with the history and structure of the

* Πλειων, more, and Καινος, recent.

† Μειων, less. ‡ Ηως, dawn.

globe, do not necessarily depend upon the opinions which may be entertained of the more controverted points of geological theory, while the science of comparative anatomy exists alone, self-contained and independent of geology. But all must agree in admitting the important service which Osteology has rendered to geological inquiries, and in rejoicing at the influence which it has had upon those who pursue such speculations, in promoting a more careful study of facts, and recommending a wise postponement of theoretical reasoning, until the season arrives when a sufficient foundation for induction shall have been laid by the patient observer.

NOTES ON THE FOSSIL OSTEOLOGY.

NOTE I.

As some learned men are satisfied with the proofs of an ape's jaw-bone having been found at Sansan, in the south-west of France, and an astragalus of the same genus in the Sivalik hills, it is very possible that this genus may be added to those found in the strata of the Miocene period; for it is only in the more recent formations that these remains are exposed to exist. That they should be found in any of the Pliocene formations is in a high degree improbable; and even then we have only got to the middle of the Tertiary period. No one contends that in the earlier formations any such remains are to be traced.

But in case any objection should be raised to the argument in the text, upon the supposition that, because quadrumanous animals were supposed by Cuvier not to be traceable in any but the present portions of the globe's crust, therefore human remains may likewise hereafter be found in earlier formations, we may remark that, even if they were, contrary to every probability, there found, no one pretends to expect such remains in those strata where no mammalia of any kind have been discovered; and the argument in the text is wholly independent of the particular period at which the non-existence of our race is admitted. These considerations are fit to be borne in mind, since learned men, like Mr. Schmerling, are inclined to think that some human bones found in the same caves with the remains of hyænas and other animals, are of contemporaneous origin. The great majority of geologists, however, refer the animals in question to the last geological era before the creation of man.

NOTE II.

THE state of rapid and solid advancement in which the science of Palæontology now is, may make the summary of its doctrines in any one year little applicable to the next. The notes to the Analysis of Cuvier, and the subsequent account of the labours of his successors, may serve to show what inhabitants of the former surface of the earth are at present within our knowledge. But with respect to the two important classes of ichthyosaurus and plesiosaurus, the following abstract will prove convenient to the student who would compare the present state of our information upon these two fossil genera at present with what it was when Cuvier wrote. Nothing can better exhibit the rate, as it were, at which this science has been advancing. I am indebted to my learned, able, and excellent friend, Mr. Greenough, for this summary, which will be found to be marked with the accuracy, the clearness, and the conciseness which distinguish all his productions:—

ICHTHYOSAURUS.

1. Communis,.......Cuvier, vol. ii. Lias—England and Wurtemberg.
2. Coniformis,.......(See Journal of Acad. of Philadelphia.) Not known to Cuvier. Lias—Bath.

3. Grandipes,........(Geol. Proc., 1830.) Not known to Cuvier.
4. Intermedius, ...Lias—England and Wurtemberg.
5. Platyodon, ...Lias—England and Wurtemberg.
6. Tenuirostris, ...Lias—England and Wurtemberg.
7. Ichthyosaurus,...Kimmeridge clay.
8. Ichthyosaurus,...Muschelkalk—Luneville and Mannsfield.

PLESIOSAURUS.

1. Goldfussii,........Quarries of Solenhofen. Not known to Cuvier.
2. Carinatus, ...Lias—England and Boulogne.
3. Dolichodeirus, ...Muschelkalk—Germany; and lias—England.
4. Pentagonus,.......Jura beds—France.
5. Profundus, ...Variegated sandstone—Jura. Not known to Cuvier.
6. Recentior, ...Kimmeridge clay.
7. Trigonus, ...Calvados—North of France.
8. Trigonus, ...Cuvier, vol. ii., p. 486. Lias, probably.

GENERAL NOTE RESPECTING EVIDENCES OF DESIGN.

ALL the inquiries in which we have been engaged lead to one conclusion of great importance. Notwithstanding the progress which has been made in various sciences, the things which have been discovered and ascertained bear an infinitely small proportion to those of which we are still either wholly ignorant, or imperfectly and dubiously informed. In a vast variety of instances, design and intelligence have been traced—instances so well deserving to be called innumerable, that we are entitled to believe in contrivance as the universally prevailing rule, and we never hesitate so to conclude. But the mode and manner of the working is still, in a prodigious number of cases, concealed from us; and we are entitled to infer that numberless things which now seem irregular, that is arranged according to no fixed rule, are nevertheless really disposed in an order which we have not discovered, which would, if we knew all, be as complete as that observed and traced in the cases known to us. Thus the regular working of bees, which we have been examining, is reducible to certain known rules; the figures formed by them are, in all their relations, familiar to mathematicians. The problems of maxima and minima, on the solution of which those operations proceed, may have parallels in the case of other animals; it is not at all improbable that the beaver forms his dike for protection against the water upon some such principle, namely, of the form which is better than any other conceivable form calculated to oppose a solid resistance to the pressure of water.* It appears probable that the works of

* The base of the dike being 12, the top 3 feet thick, and the height 6 feet, the face is the side of a right angled triangle, whose height is 8 feet; and if the materials were lighter than water in the proportion of 44 : 100, this construction would be the best one conceivable to prevent the dam from turning round. But the form flatter than that which would best serve this purpose when the materials are heavier than water, is probably taken to prevent the dam from being shoved forward.

spiders in concentric circles, and along their radii, are also regularly arranged in known figures, and upon similar principles. Many of the parts of plants wear the semblance of regular and symmetrical curve lines, insomuch that a mathematician once presented a paper to the Royal Society (on some propositions in the higher geometry), which he entitled, from the form of the lines investigated, 'Fasciculus Florum Geometricorum.' The orbits in which the heavenly bodies move, come manifestly within the same remark still more certainly; for the forms of those paths, the relation of all their points to given straight lines, is in a great degree ascertained. But it seems very reasonable to conclude, that the small number of such regular figures which the state of science in its various branches has as yet enabled us to trace, is as nothing compared with those figures still so unknown to us, that in common speech we talk of them as irregular, while this is only a word, like chance, implying our own ignorance.

For the mathematical sciences, extraordinary as the progress already made may be reckoned, with regard to the difficulty of the subject, and the imperfect faculties of man, are most probably still in their infancy. Of the infinite variety of curve lines, we know but a very few with any particularity, to say nothing of our equal ignorance (connected with the former) of most of the laws of complex motion. In the parts of animal and vegetable bodies, especially of the larger kind, there are few symmetrical forms observed; greater convenience, in the former instance at least, is evidently attained by other shapes. Yet there seems no reason to doubt that all the forms which we see may be in reality perfectly regular, that is, that each outline is a curve, or portion of a curve, related to some axis, so that each of its parts shall bear the same relation to lines similarly drawn from it to this axis, which all its other points do. If we know little of algebraical curves, we know still less of those whose structure is not expressible by the relations of straight lines and numbers, the class called mechanical or transcendental, the forms of some of which are very extraordinary, but all whose points are related together by the same law. There is every reason to expect that the further progress of science will unfold to us much more of the principles upon which the forms of matter, both organic and inorganic, are disposed, so that the order pervading the system may be far more clearly perceived.

So of motion—In one most important branch, dynamics is still in its infancy; we know little or nothing of the minute motions by which the particles of matter are arranged, when bodies act chemically on each other. Even respecting the motions of fluids so much studied as electricity, and heat (if it be a fluid), and the operation of the magnetic influence, science is so imperfect, and our data from observation so scanty, that mathematical reasoning has as yet hardly ever been applied to the subject. It is the hope of men who reflect on these things, and it is probably the expectation of those who most deeply meditate upon them, that, in future times, a retrospect upon the fabric of our present knowledge, shall be the source of wonder and compassion—wonder at the advances made from such small beginnings—compassion for the narrow sphere within which our knowledge is confined:—and when the greater part of what we are now only able to believe regular and systematic from analogy and conjecture, will have fallen into an order and an arrangement certainly known and distinctly perceived.

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